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THE

OCEAN WORLD:

BEING A DESCRIPTION OF

The Sea and some of its Inhabitants.

FROM THE FRENCH OF

LOUIS FIGUIER.

NEW EDITION, REVISED BY

E. PERCEVAL WRIGHT, M.D., F.L.S.,

Professor of Botany in the University of Dublin.

WITH 435 ILLUSTRATIONS.

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PREFACE.

A NEW edition of this work having been called for, I was requested to revise it and see it through the press.

The attempt to render scientific subjects popular and attractive to the general reader has always appeared to me a most laudable one. It has always received the support of our most original workers and deepest thinkers; and yet, so far as the English language is concerned, the attempt to make zoological science familiar to the ordinary reader has, in my opinion, most generally been a failure. Such essays as the "Studies of Animal Life," by G. H. Lewes, were indeed full of promise; but such served scarcely more than to introduce the reader to the very threshold of the science, though they at the same time showed what thoroughly good work could be done in this direction by our British scientific men.

In the meanwhile, a series of most attractive works on biological science, and beautifully illustrated, was being published in France, some written or edited by names well known in the fields of scientific research, others—as those by M. Figuier—by men eloquent after the fashion of their countrymen, but much wanting in that exact knowledge of the sciences about which they wrote, and which would have enabled them to avoid falling into many and grievous errors.

With the faint hope that I would have no difficulty in simply retaining the text that helps to explain the in general excellent woodcuts that illustrate the present volume, I undertook to revise it. Those familiar with the subject will perhaps appreciate the statement that, as it proved, it would have been an easier and certainly a more pleasant task to have re-written the work. Those who will compare the present edition with that of 1869, will see that the alterations in this one have been very numerous and important, several chapters being nearly re-written; that all the dogmatic assertions, so striking in the edition of 1869, have been toned down in conformity with that modesty that should characterise the searchers after truth; and that the more rampant twigs of French eloquence have been pruned in conformity with our quieter if not better taste. Would that I could add that they will also find all errors corrected, but of the contrary I am painfully aware. At the same time, I believe the candid critic will see that if in this matter I have not done all I should, I have at least, under all the circumstances, done all I could.

I am indebted to my friend, G. J. Stoney, M.A., F.R.S., for the short account of the cause of the tides, to be found on pages 32 to 35. Perhaps never before has the subject been treated in a more popular and yet scientific a way.

E. P. W.

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THE OCEAN WORLD.

CHAPTER I.

THE OCEAN.

Ἄριστον μὲν ὕδωρ—"The best of all things is water."—PINDAR.

It is estimated that the sea covers nearly two-thirds of the surface of the earth. The calculation, as given by astronomers, is as follows: The surface of the earth is 31,625,625$\frac{1}{12}$ square miles, that portion occupied by the waters being about 23,814,121 square miles, and that consisting of continents, peninsulas, and islands, being 7,811,504 miles; whence it follows that the surface covered with water is to dry land as 3·8 is to 1·2. The waters thus cover a little more than seven-tenths of the whole surface. "On the surface of the globe," Michelet remarks, "water is the rule, dry land the exception."

Nevertheless, the immensity and depth of the seas are aids rather than obstacles to the intercourse and commerce of nations; the maritime routes are now traversed by ships and steamers conveying cargoes and passengers equal in extent and in point of numbers to the land routes. One of the features most characteristic of the ocean is its continuity; for, with the exception of inland seas, such as the Caspian, the Dead Sea, and some others, the ocean is one and indivisible—"it embraces the whole earth with an uninterrupted wave."

Περὶ πᾶσαν θ' εἱλισσομένους
χθόν' ἀκοιμήτῳ ῥεύματι.

ÆSCHYLUS in *Prometheus Vinctus.*

The mean depth of the sea is not very exactly ascertained, but certain phenomena observed in the movement of tides are supposed to be incapable of explanation without admitting a mean depth of

3,500 fathoms. It is true that a great number of deep-sea soundings fall short of that limit; but, on the other hand, many others reach 7,000 or 8,000. Admitting that 3,000 fathoms represent the mean depth of the ocean, Sir John Herschel finds that the volume of its waters would exceed 3,279,000,000 cubic yards.

This vast volume of water is divided by geographers into five great oceans: the Arctic, the Atlantic, Indian, Pacific, and Antarctic Oceans.

The Arctic Ocean extends from the Pole to the Polar Circle; it is situated between Asia, Europe, and America.

The Atlantic Ocean commences at the Polar Circle, and reaches Cape Horn. It is situated between America, Europe, and Africa, in length of about 9,000 miles, with a mean breadth of 2,700, covering a surface of about 25,000,000 square miles, placed between the Old World and the New. Beyond the Cape of Storms, as Cape Horn may be truly called, it is only separated by an imaginary line from the vast seas of the south, in which the waves, which are the principal source of tides, have their birth. Here, according to Maury, the young tidal wave, rising in the circumpolar seas of the south, and obedient to the sun and moon, rolls on to the Atlantic, and in twelve hours after passing the parallel of Cape Horn is found pouring its flood into the Bay of Fundy, whence it is projected in great waves across the Atlantic and round the globe, sweeping along its shores and penetrating its gulfs and estuaries, rising and falling in the open sea two or three feet, but along the shore having a range of ten or twelve feet; sometimes, as at Fundy on the American coast, at Brest on the French coast, and Milford Haven and the mouth of the Severn in the Bristol Channel, rising and falling thirty or forty feet, "impetuously rushing against the shores, but gently stopping at a given line, and flowing back to its place when the word goes forth, 'Thus far shalt thou go and no farther.' That which no human power could repel returns at its appointed time so regularly and surely, that the hour of its approach and the measure of its mass may be predicted with unerring certainty centuries beforehand."

The Indian Ocean is bounded on the north by Asia, on the west by Africa, on the east by the peninsula of Molucca, the Sunda Isles, and Australia.

The Pacific, or Great Ocean, stretches from north to south, from the Arctic to the Antarctic Circle; being bounded on one side by Asia, the island of Sunda, and Australia, on the other by the west coast of America. This ocean contrasts in a striking manner with the Atlantic: the one has its greatest length from north to south, the

other from east to west; the currents of the Pacific are broad and slow, those of the other narrow and rapid; the waves of this are low, those of the other very high. If we represent the volume of water which falls into the Pacific by one, that received by the Atlantic will be represented by the figure five. The Pacific is the calmest of seas, and the Atlantic Ocean is the most stormy.

The Antarctic Ocean extends from the Antarctic Polar Circle to the South Pole.

It is remarkable that one half of the globe should be entirely covered with water, whilst the other contains less of water than dry land; moreover, the distribution of land and water—if, in considering the extent of the oceanic basins, we compare the hemispheres separated by the Equator and the northern and southern halves of the globe—is found to be very unequal.

Oceans communicate with continents and islands by coasts, which are said to be scarped when a rocky coast makes a steep and sudden descent to the sea, as, for example, in Brittany, Norway, and the west coast of the British Islands. In this kind of coast certain rocky indentations encircle it, sometimes above, sometimes under water, forming a labyrinth of islands, as at the Land's End, Cornwall, where the Scilly Islands form a compact group of from 100 to 200 rocky islets, rising out of a deep sea. The coast is said to be flat when it consists of soft argillaceous soil descending to the shore with a gentle slope. Of this description of coast there are two—namely, sandy beaches, and hillocks or dunes.

What is the average depth of the sea? It is difficult to give an exact answer to this question, because of the great difficulty met with in taking soundings, caused chiefly by the deviations of submarine currents. No reliable soundings have yet been made in water over five miles in depth.

Laplace found, on astronomical consideration, that the mean depth of the ocean could not be more than 10,000 feet. Alexander von Humboldt adopts the same figures. Dr. Young attributes to the Atlantic a mean depth of 1,000 yards, and to the Pacific, 4,000. Mr. Airy, the Astronomer Royal, has laid down a formula, that waves of a given breadth will travel with certain velocities at a given depth, from which it is estimated that the average depth of the North Pacific, between Japan and California, is 2,149 fathoms, or two miles and a half. But these estimates fall far short of the soundings reported by navigators, in which, however, as we shall see, there are important and only recently-discovered elements of error. Du Petit

Thouars, during his scientific voyage in the frigate *Venus*, took some very remarkable soundings in the Southern Pacific Ocean: one, without finding bottom at 2,411 fathoms; another, in the equinoctial region, indicated bottom at 3,790.

In his last expedition in search of a north-west passage, Captain Ross found soundings at 5,000 fathoms. Lieutenant Walsh, of the American Navy, reports a cast of the deep-sea lead, not far from the American coast, at 34,000 feet without bottom. Lieutenant Berryman reported another unsuccessful attempt to fathom mid ocean with a line 39,000 feet in length. Captain Denman, of H.M.S. *Herald*, reported bottom in the South Atlantic at the depth of 46,000 feet; and Lieutenant J. P. Parker, of the United States frigate *Congress*, on attempting soundings near the same region, let go his plummet, after it had run out a line 50,000 feet long, as if the bottom had not been reached. We have the authority of Lieutenant Maury for saying, however, that "there are no such depths as these." The under-currents of the deep sea have power to take the line out long after the plummet has ceased to sink, and it was before this fact was discovered that these great soundings were reported. It has also been discovered that the line, once dragged down into the depths of the ocean, runs out unceasingly. This difficulty was finally overcome by the ingenuity of Midshipman Brooke. Under the judicious patronage of the Secretary to the United States Navy, Mr. Brooke invented the simple and ingenious apparatus (Fig. 1), by which sound ngs are now made, in a manner which not only establishes the depth, but brings up specimens of the bottom. The sounding line in this apparatus is attached to a weighty rod of iron, the lower extremity of which contains a hollow cup for the reception of tallow or some other soft substance. This rod is passed through a hole in a thirty-two pound spherical shot, being supported in its position by slings A, which are hooked on to the line by the swivels *a*. When the rod strikes the bottom, the tension on the line ceases, the swivels are reversed, the slings B are thrown out of the hooks, the ball falls to the ground, and the rod, released from its weight, is easily drawn up, bringing with it portions of the bottom attached to the greasy substance in the cup. By means of this apparatus, specimens of the bottom have been brought up from the depth of four miles.

The greatest depth at which the bottom has been reached with this plummet is in the North Atlantic between the parallels of 35° and 40° north, and immediately south of the great bank of rocks off Newfoundland. This does not appear to be more than 20,000 feet deep. "The basin of the Atlantic," says Maury,

"according to the deep-sea soundings in the accompanying diagram, is a long trough separating the Old World from the New, and extending, probably, from pole to pole. In breadth it contrasts strongly with the Pacific Ocean. From the top of Chimborazo to

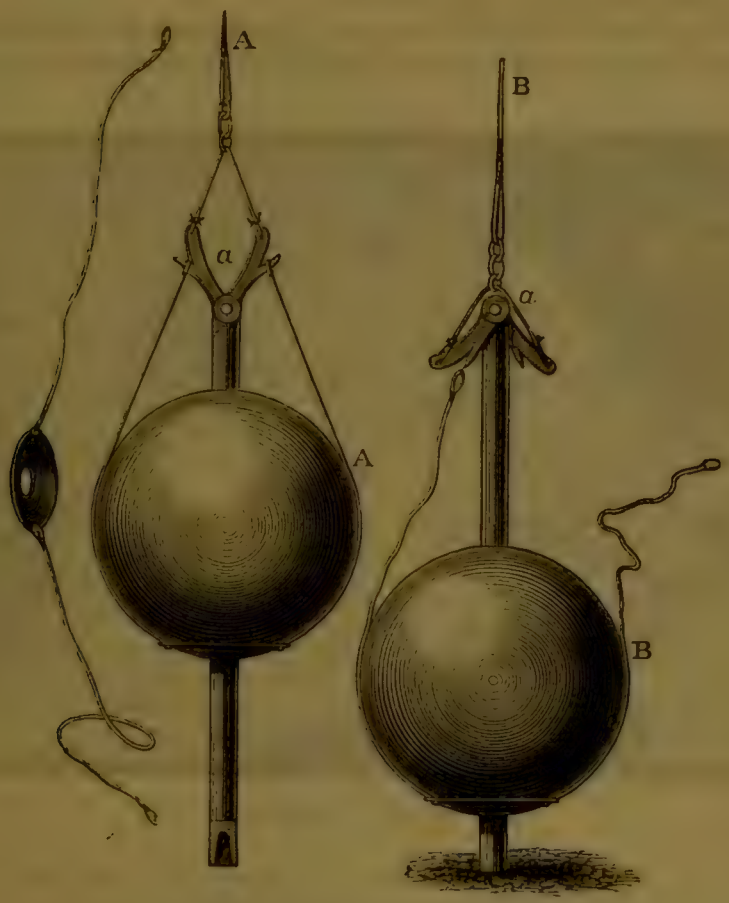


Fig. 1.—Brooke's Sounding Apparatus

the bottom of the Atlantic, at the deepest place yet reached by the plummet in that ocean, the distance in a vertical line is nine miles."

"Could the waters of the Atlantic be drawn off, so as to expose to view this great sea gash which separates continents, and extends from the Arctic to the Antarctic Seas, it would present a scene the most rugged, grand, and imposing; the very ribs of the solid earth

with the foundations of the sea would be brought to light, and we should have presented to us in one view, in the empty cradle of the ocean, 'a thousand fearful wrecks,' with the array of 'dead men's skulls, great anchors, heaps of pearls, and inestimable stones,' which, in the poet's eye, lie scattered on the bottom of the sea, making it hideous with the sight of ugly death."

The depth of the Mediterranean is comparatively inconsiderable. Between Gibraltar and Ceuta, Captain Smith estimates the depth at

Fig 2.—Chart of the Atlantic Ocean.

about 5,700 feet, and from 1,000 to 3,000 in the narrower parts of the straits. Near Nice Saussure found bottom at 3,250. It is said that the bottom is shallower in the Adriatic, and does not exceed 140 feet between the coast of Dalmatia and the mouths of the Po.

The Baltic Sea is remarkable for its shallow waters, its maximum depth rarely exceeding 600 feet.

It thus appears that the sea has similar inequalities to those observed on land; it has its mountains, valleys, hills, and plains.

The deep-sea sounding apparatus of Lieutenant Brooke has already furnished some very remarkable results. Aided by it,

Dr. Maury has constructed his fine orographic map of the basin of the Atlantic. Dr. Maury has also published many charts, giving the depths of the ocean, the substance of which is given in the accompanying map, which represents the configuration of the Atlantic up to the tenth degree of south latitude, not in figures, as in Dr. Maury's charts, but in tints; diagonal lines from right to left, representing the shores of both hemispheres, indicate a depth of less than 1,000 fathoms; from left to right indicate bottom at 1,000 to 2,000; horizontal lines, 2,000 to 3,000 fathoms; cross lines show an average depth of 3,000 to 4,000 fathoms; finally, the perpendicular lines indicate a depth of 4,000 fathoms and upwards. Solid black indicates continents and islands; waving lines, surrounding both continents at a short distance from the shore, indicate the sands which surround the coast line at a little distance from the shore.

The question may be asked, what useful purpose is served by taking soundings at great depths? To this we may quote the answer of Franklin to a question of similar tendency, addressed to aëronauts—"What purpose is served by the birth of a child?" Every fact in physics is interesting in itself; it forms a rallying point, round which, sooner or later, others will meet, in order to establish some useful truth; and the importance of making and recording deep-sea soundings is established by the successful immersion of the transatlantic telegraph.

At the bottom of the Atlantic there exists a remarkable plateau, extending from Cape Race in Newfoundland, to Cape Clear in Ireland, a distance of over 2,000 miles, with a breadth of 470 miles; its mean depth along the whole route is estimated at two miles and a half. It is upon this telegraphic plateau, as it has been called, that the attempt was made to lay down the cable in 1858, and it is on it that the enterprise was so successfully completed during the year 1866. The surface of the plateau had been previously explored by means of Brooke's apparatus, and the bottom was found to be composed chiefly of microscopic calcareous shells (*Foraminifera*), and a few siliceous shells (*Diatomaceæ*). These delicate and fragile shells, which seemed to strew the bottom of the sea in beds of great thickness, were brought up by the sounding-rod in a state of perfect preservation, which proves that the water is remarkably quiet in these depths—an inference which is fully borne out by the condition in which the cable of 1858 was found, when picked up in 1866.

The first exploration of this plateau was undertaken by the American brig *Dolphin*, which took 100 soundings 100 miles from

Fig. 3.—Section of the Atlantic, showing its depth, and the position of the Atlantic Telegraph.

the coast of Scotland, afterwards taking the direction of the Azores, to the north of which bottom was found, consisting of chalk and yellow sand, at 9,600 feet. To the south of Newfoundland the depth was found to be 16,500 feet. In 1856, Lieutenant Berryman, of the American steamer *Arctic*, completed a line of soundings from St. John, Newfoundland, to Valentia, off the Irish coast; and in 1857, Lieutenant Dayman, of the English steamship *Cyclops*, repeated the same operation: this last line of soundings, the result of which is represented in the accompanying section, differed slightly from that followed by Lieutenant Berryman. In the Gulf of Mexico the depth does not seem to exceed 7,000 feet.

The Arctic Ocean has, probably, no great depth. Hence, salt water, following the general law of contracting as it cools, until it freezes, no ice can be formed on its surface till the temperature has fallen through its entire depth nearly to freezing point, when the entire mass is consolidated into pack-ice. According to Baron Wrangel, the bottom of the glacial sea, on the north coast of Siberia, forms a gentle slope, and, at the distance of 200 miles from the shore, it is still only from ninety to 100 feet. Nevertheless, in Baffin's Bay, Dr. Kane made soundings at 11,600 feet.

The inequalities of the basin of the Pacific Ocean are, comparatively, unknown to us. The greatest depth observed by Lieutenant Brooke in the great ocean is 2,700 fathoms, which he found in 59° north latitude and 166° east longitude. Applying the theory of waves to the billows propelled from the coast of Japan to California, during the earthquake of the 23rd of December, 1854, Professor Bache calculated that the mean depth of this part of the Pacific is 14,400 feet. In the Pacific Ocean, latitude 60° south and 160° east longitude, he found soundings at 14,600 feet—about two miles and a half. Another cast of the lead in the Indian Ocean was made in 7,040 fathoms, but without bringing up any soil from the bottom. Among the fragments brought up from the bottom of the Coral Sea, a remarkable absence of calcareous shells was noted, whilst the siliceous fragments of sponges were found in great quantities. Other soundings made in the Pacific, at a depth of four or five

miles, were examined by Ehrenberg, who found 135 different forms of Infusoria represented, and among them twenty-two species new to him. These Protozoa draw from the sea the mineral matter with which it is charged—that is, the lime or the silica, which form their shell. These shells accumulate after the death of the animal, and form the bottom of the ocean. The animals construct their habitations near the surface; when they die, they fall into the depths of the ocean, where they accumulate in myriads, forming mountains and plains in mid ocean. In this manner, we may remark *en passant*, many of the existing continents probably had their birth in geological times. The horizontal beds of marine deposits, which are called *sedimentary rocks*, and especially the cretaceous rocks and calcareous beds of the Jurassic and Tertiary periods, all result from such remains.*

The sea level is, in general, the same everywhere. It represents the spherical form of our planet, and is the basis for calculating all terrestrial heights; but many gulfs and inland seas open on the east are supposed to be exceptions to this rule: the accumulation of waters, pressed into these receptacles by the general movement of the sea from east to west, it is alleged, may pile up the waters, in some cases to a greater height than the general level.

It had long been admitted, on the faith of inexact observation, that the level of the Red Sea was higher than that of the Mediterranean. It has also been said that the level of the Pacific Ocean at Panama is higher by about forty inches than the mean level of the Atlantic at Chagres, and that, at the moment of high water, this difference is increased to about thirteen feet, while at low it is over six feet in the opposite direction. This has been proved, so far as direct evidence goes, to be an error in so far as regards the difference in level of the Red Sea and Mediterranean; and the opening of the Suez Canal has now furnished convincing proofs of it. Recent soundings show that the mean level of the Pacific and Atlantic Oceans are identical.

It has been calculated that all the waters of the several seas gathered together would form a sphere of fifty or sixty leagues in diameter, and, supposing the surface of the globe perfectly level, that these waters would submerge it to the depth of more than 600 feet. Again, admitting the mean depth of the sea to be 13,000 feet, its estimated contents ought to be nearly 2,250,000,000 of cubic miles of water; and, if the sea could be imagined to be dried up, all

* "World Before the Deluge," 2nd edition.

the rivers of the earth would require to pour their waters into it for 40,000 years, in order to fill the vast basins anew.

If we could imagine the entire globe to be divided into 1,786 parts by weight, we should find approximately, according to Sir John Herschel, that the total weight of the oceanic waters is equivalent to one of these parts.

The specific density of sea water is a little above that of fresh water, the proportion being as 1,000 to 1,027. The Dead Sea, which receives no fresh water so as to enable it to maintain itself at the same level as other seas, acquires a higher degree of saltness each year: its present density is equal to 1,028.

The colour of the sea is continually varying, and is chiefly caused by filtration of the solar rays. According to the testimony of the majority of observers, the ocean, seen by reflection, presents a fine azure blue or ultramarine (*cæruleum mare*). When the air is pure and the surface calm, this tint softens insensibly, until it is lost and blended with the blue of the heavens. Near the shore it becomes more of a green or glaucous tint, and more or less brilliant, according to circumstances. There are some days when the ocean assumes a livid aspect, and others when it becomes a very pure green; at other times, the green is sombre and sad. When the sea is agitated, the green takes a brownish hue. At sunset the surface of the sea is illumined with tints of every hue of purple and emerald. Placed in a vase, sea water appears perfectly transparent and colourless. According to Scoresby, the Polar seas are of brilliant ultramarine blue. Castaz says of the Mediterranean, that it is celestial blue, and Tuckey describes the equinoctial Atlantic as being of a vivid blue.

Many local causes influence the colours of marine waters, and give them certain decided and constant shades. A bottom of white sand will communicate a greyish or apple-green colour to the water, if not very deep; when the sand is yellow, the green appears more sombre; the presence of rocks is often announced by the deep colour which the sea takes in their vicinity. In the Bay of Loango the waters appear of a deep red, because the bottom is there naturally red. It appears white in the Gulf of Guinea, yellow on the coast of Japan, green to the west of the Canaries, and black round the Maldive group of islands. The Mediterranean, towards the Grecian Archipelago, sometimes becomes more or less red. The White and Black Seas appear to be named after the ice of the one and the tempests to which the other is subject.

At other times coloured animal or vegetable bodies give to the water a particular tint. The Red Sea owes its colour to a minute microscopic algæ (*Trichodesmium erythræum*), which was examined under the microscope by Ehrenberg; but various other causes of its colouration have been suggested. Some microscopists maintain that it is imparted to it by the presence of minute Infusoria; others, again, ascribe its colour to the fact that the evaporation which goes on unceasingly in that riverless district produces reddish salt rocks on a great scale all round its shores. In the same manner sea water, concentrated by the action of the solar rays in the salt marshes of the south of France, when they arrive at a certain stage of concentration, take a fine red colour, which, however, is due to the presence of a species of red-shelled Entomostracon which only appear in sea water of this strength. The red saline lakes on the Great Thibetian watersheds are also said to be due to this cause. Strangely enough, these minute creatures die when the waters attain greater density by further concentration, and also if it becomes weaker from the effects of rain.

Navigators often traverse long patches of green, red, white, or yellow coloured waters, their colouration being consequent on the presence of microscopic crustaceans, medusæ, zoophytes, and marine plants—the Vermilion Sea on the Californian coast is probably due to the latter cause.

The phenomenon known as *Phosphorescence of the Sea* is due to analogous causes. This wonderful sight is observable in all seas, but is most striking in the Indian Ocean, the Arabian Gulf, and other tropical seas. In the Indian Ocean, Captain Kingman, of the American ship *Shooting Star*, traversed a zone twenty-three miles in length so filled with phosphorescent matter, that a little before eight o'clock at night, the water was seen rapidly assuming a white, milky appearance, and during the night it presented the appearance of a vast field of snow. "There was scarcely a cloud in the heavens," he continues, "yet the sky, for about 10° above the horizon, appeared as black as if a storm were raging; stars of the first magnitude shone with a feeble light, and the 'Milky Way' of the heavens was almost entirely eclipsed by that through which we were sailing." Some of the animals which produced this appearance were thought to be about six inches long, and appeared formed of a gelatinous and translucent matter. At times, the sea was one blaze of light, produced by countless millions of those minute globular creatures, called *Noctiluca*. The motion of a vessel or the splash of

an oar will often excite their luminosity, and sometimes, after the ebb of tide, the rocks and seaweed of the coast will be found glowing with them. Various other tribes of animals there are which contribute to this luminous appearance of the sea. M. Peron thus describes the effect produced by *Pyrosoma atlanticum*, on his voyage to the Isle of France :—"The wind was blowing with great violence, the night was dark, and the vessel was making rapid way, when what appeared to be a vast sheet of phosphorus presented itself floating on the waves, and occupying a great space ahead of the ship. The vessel having passed through this fiery mass, it was discovered that the light was occasioned by organised bodies swimming about in the sea at various depths round the ship. Those which were deepest in the water looked like red-hot balls, while those on the surface resembled cylinders of red-hot iron. Some of the latter were caught: they were found to vary in size from three to seven inches. All the exterior of the creatures bristled with long thick tubercles, shining like so many diamonds, and these seemed to be the principal seat of their luminosity. Inside also there appeared to be a multitude of oblong narrow glands, exhibiting a high degree of phosphoric power. The colour of these animals when in repose is an opal yellow, mixed with green ; but, on the slightest movement, the animal exhibits a spontaneous contractile power, and assumes a luminous brilliancy, passing through various shades of deep red, orange green, and azure blue."

The phosphorescence of the sea is a spectacle at once imposing and magnificent. A ship, in plunging through the waves, seems to advance through a sea of bright flame, which is thrown off by the keel like so much lightning. Myriads of phosphorescent creatures float and play on the surface of the waves, so as to form one vast field of fire. In stormy weather the luminous waves roll and break in a silvery foam. Glittering particles, which might be taken for sparks of living fire, seem to pursue and catch each other—lose their hold, and dart after each other anew. From time immemorial, the phosphorescence of the sea has been observed by navigators. The luminous appearance presents itself on the crest of the waves, which in falling scatter it in all directions. It attaches itself to the rudder, and dashes against the bows of the vessel. It plays round the reefs and rocks against which the waves beat, and on silent nights, in the tropics, the effects are truly magical. This phosphorescence is due for the most part to the presence of a multitude of Noctiluca, larval crustacean forms, some few Molluscs and Acalephes, which seem to shine by their own light. Of the most remarkable of the molluscs met with are several species of *Pyrosoma* which present the

appearance of a sort of mucous sac of about an inch long, which, thrown upon the deck of a ship, emits a light like a rod of iron heated to a white heat. Sir John Herschel noted on the surface of calm water a very curious form of phosphorescence; it was a polygon of rectilinear shape, covering many square feet of surface, and it illuminated the whole region for some moments with a vivid light, which traversed it with great rapidity.

The phosphorescence of the sea may also result from another cause. When animal matter is decomposed it becomes phosphorescent. The bodies of certain fishes, when they become a prey to putrefaction, emit an intense light. MM. Becquerel and Breschet have noted fine phosphorescent effects from this cause in the waters of the Brenta at Venice. Animal matter in a state of decomposition, proceeding from dead fish which floats on the surface of ponds, is capable of producing large patches of oleaginous matter, which, piled upon the water, communicates, to a considerable extent, especially when the water is agitated, a phosphorescent appearance.

Whatever may be the case elsewhere, there are local causes which affect the colour of the waters in certain rivers, and even originate their names. The Guaïnia, which with the Casiquaire forms the Rio Negro, is of a deep brown, which scarcely interferes with the limpidity of its waters. The waters of the Orinoco and the Casiquaire have also a brownish colour. The Ganges is of a muddy brown, while the Djumna, which it receives, is green or blue. A whitish colour is characteristic of the Rio Bianco, or White River, and of many other rivers. The Ohio in America, the Torgedale, the Goetha, the Traun at Ischl and most of the Norwegian rivers, are of a delicate limpid green. The Yellow River and the Blue River in China are distinguished by the characteristic tint of their waters. The Arkansas, the Red River, and the Lobregat in Catalonia, are remarkable for their red colour, which, like the Dart and other English rivers, they owe to the earth over which they flow, or which their waters hold in suspension.

The water of the sea is essentially *salt*, of a peculiar flavour, slightly acrid and bitter, and a little nauseous. It has an odour peculiarly its own, and is slightly viscous. In short, it includes a great number of mineral salts, which give it a very disagreeable taste, and render it unfit for domestic use. It contains, among the soluble substances which exist on the globe, principally chloride of sodium, and sulphates of magnesia, of potassium, and of lime.

Pure water is produced by a combination of one volume of oxygen and of two volumes of hydrogen, or in weight, 100 oxygen, 12·50 hydrogen. Sea water is composed of the same; but we find there, besides, other elements, the presence of which chemistry reveals to us. In 1,000 grains of sea water the following ingredients are found :—

Water	962·0
Chloride of sodium	27·1
Chloride of magnesium	5·4
Chloride of potassium	0·4
Bromide of magnesia	0·1
Sulphate of magnesia	1·2
Sulphate of lime	0·8
Carbonate of Lime	0·1

leaving a residuum of 2·9, consisting of sulphuretted hydrogen, hydrochlorate of ammonia, iodine, iron, copper, and even silver in various quantities and proportions, according to the locality of the specimen. In examining the plates of copper taken from the bottom of a ship at Valparaiso, which had been long at sea, distinct traces of silver were found deposited by the sea. Finally, we find dissolved in the ocean a peculiar mucus, which seems of a mixed animal and vegetable nature, and is apparently organic matter proceeding from the successive decomposition of the innumerable generations of animals which have disappeared since the beginning of the world. This matter has been described by the Count Marsigli, who designates it sometimes under the name of *glu*, and sometimes as an *unctuosity*. It is the "ooze" of marine surveyors, and consists chiefly of carbonate of lime, ninety per cent. of which is formed of minute animal organisms. Its mealy adhesiveness results from the pressure of the superimposed water. The numerous salts which exist in the sea can neither be deposited in its bed, nor exhaled with the vapour, to be again poured upon the soil in showers of rain. Particular agents retain these salts in solution, transform them, and prevent their accumulation. Hence sea water always maintains a certain degree of saltness and bitterness; and the ocean continues to present the chemical characters which it has exhibited in all times, varying only in certain localities where more or less fresh water is poured into the sea basin from rivers; thus, the saltness of the Mediterranean is greater than that of the open ocean, probably because it loses more water by evaporation than it receives from its fresh-water affluents. For the opposite reason, the Black and the Caspian Seas are less charged with these salts. The Dead Sea is so strongly

impregnated with salt that the body of a man floats on its surface without sinking, like a piece of cork upon fresh water. The supposed causes are excessive evaporation and the absence of rivers of any importance.

The saltness of the sea seems to be generally less towards the poles than the equator; but there are exceptions to this law. In the Irish Channel, near the Cumberland coast, the water contains salt equal to the fortieth of its weight; on the coast of France it is equal to one thirty-second; in the Baltic it is equal to a thirtieth; at Teneriffe a twenty-eighth; and off the coast of Spain to a sixteenth. Again, in many places the sea is less salt at the surface than at the bottom. In the Straits of the Dardanelles at Constantinople the proportion is as seventy-two to sixty-two; in the Mediterranean it is as thirty-two to twenty-nine. It is also stated that as the salt increases at a certain depth the water becomes less bitter. At the mouths of the great rivers, it is scarcely necessary to add, the water is always less saline than on shores which receive no supplies of fresh water; the same remark applies to sea water in the vicinity of polar ice, the melting of which is productive of much fresh water. A recent analysis of the water of the Dead Sea by M. Roux gives about two pounds of salt to one gallon of water; no mineral water, if we except that of the Salt Lake of Utah, is so largely impregnated with saline substances; the quantity of bromide of magnesia is 0·35 grammes to the litre. The water of the Dead Sea is, according to these proportions, a rich natural depository of bromide, which it might be made to furnish abundantly. The waters of the great Lake of Utah and Lake Ourmiah in Persia are both highly saline. In Lake Ourmiah, as in the Dead Sea, the proportion of salt is six times greater than in the ocean. Many of our fresh-water lakes were probably salt originally, but have by degrees lost their saline properties by the mingling of their waters with those of the rivers which traverse or flow into them. Among the lakes which appear to have been divested of their saline properties may be mentioned the great lakes of Canada and the Sea of Baikal, in all of which seals and other marine animals are still found, which have become acclimatised as the water gradually became fresh.

The saltness of sea water increases its density, and at the same time its buoyancy, thus adapting it for bearing ships and other burdens on its bosom; moreover, to abbreviate slightly Dr. Maury's remark, "the brine of the ocean is the ley of the earth." From it the sea derives dynamical power, and its currents their main strength. It is the salt of the sea that imparts to its waters those curious

anomalies in the laws of freezing and of thermal dilatation, that assist the rays of heat to penetrate its bosom; the salts of the sea invest it with adaptations which fresh water could not possess. In the latter case the maximum density would be 39° 5″ instead of 25° 6″, when the dynamical force of the sea would be insufficient to put the Gulf Stream in motion, nor could it regulate those climates we call marine.

We have said that sea water contains nearly all the soluble substances which exist in the globe. Nevertheless, when evaporated it is comparatively pure. "The water which evaporates from the sea," says Youman, in his "Chemistry," "is nearly pure, containing very minute traces of salts. Falling as rain upon the land, it washes the soil, percolates through the rocky layers, and becomes charged with saline substances, which are borne seaward by the returning currents. The ocean, therefore, is the great depository of all substances that water can dissolve and carry down from the surface of the continents; and, as there is no channel for their escape, they would constantly accumulate were it not for the creatures which inhabit the seas and utilise the material thus brought within their reach." These substances are chloride of sodium or common salt, sulphates of magnesia, potassium, lime, and other substances, which the water of various seas is found to contain.

In the year 1847 I made an analysis of water taken a few leagues from the coast at Havre, which gave the following result, from one litre (1 pint ·760773):—*

	Grammes.
Chloride of sodium	25·704
Chloride of magnesium	2·905
Sulphate of magnesia	2·462
Sulphate of lime	1·210
Sulphate of potassium	0·094
Carbonate of lime	0·132
Silicate of soda	0·017
Bromide of sodium	0·103
Bromide of magnesium	0·030
Oxide of iron, carbonate and phosphate of magnesia, and oxide of manganese	Only traces.
	32·657

* Examen Comparatif des Principales Eaux Minérales de France et d'Allemagne, par MM. L. Figuier et Mialhe. Read at the Académie de Médecin, 23rd of May, 1848.

The water of the Mediterranean contains more salts than that of the ocean.

The following are, according to M. Usiglio—who was one of a commission sent to examine the different kinds of salt water in the south of France—the component parts of one hundred gallons of Mediterranean water:—

	lbs.
Chloride of sodium	29·524
Chloride of potassium	0·405
Chloride of magnesium	3·219
Sulphate of magnesia	2·477
Chloride of calcium	6·080
Sulphate of lime	1·557
Carbonate of lime	0·114
Bromide of sodium	0·356
Protoxide of iron	0·003
	43·735

We conclude, from the quantity of sea salt contained in the water of the ocean, that if it were spread over the surface of the globe, it would form a layer of more than thirty feet in height.

The salt contained in sea water gives it a greater density than fresh water; its average specific weight is 1·027. The density of the water of the Mediterranean is, according to M. Usiglio, 1·025 when at the temperature of seventy degrees. But the saltness of the sea varies very much under the influence of a great many local circumstances, among which we must count principally currents, winds favourable to evaporation, rivers coming from the continents, &c.

It has been remarked that the sea is less salt towards the poles than at the equator; that the saltness increases, in general, with the distance from land, and the depth of the water; that the interior seas, such as the Baltic, the Black Sea, the White Sea, the Sea of Marmora, and the Yellow Sea, are less salt than the ocean. The Mediterranean is an exception to this last rule; it is, as we have seen, salter than the ocean. This difference is explained by the fact that the quantity of fresh water brought into it by rivers is less than that lost by evaporation. The Mediterranean must therefore grow salter with time, unless its water is discharged into the ocean by a counter current, which would run under the current coming from the Atlantic by the Straits of Gibraltar.

The Black Sea, on the contrary, the water of which has a density of only 1·013, receives from rivers more fresh water than it loses by

evaporation. The saltness of this interior sea is only half as intense as that of the ocean.

The Sea of Azov and the Caspian Sea are still less salt than the Black Sea.

The following table shows the relative composition of the water in these three interior seas :—

In 100 Gallons of Water.	Black Sea. Density 1·013.	Sea of Azov. Density 1·009.	Caspian Sea. Density 1·005.
Chloride of sodium . . .	14·0195	9·6583	3·6731
Chloride of potassium . .	9·1892	0·1279	0·0761
Chloride of magnesium . .	1·3045	0·8870	0·6324
Sulphate of magnesia . .	1·4704	0·7642	1·2389
Sulphate of lime	0·1047	0·2879	0·4903
Bicarbonate of magnesia . .	0·2086	0·1286	0·0129
Bicarbonate of lime . . .	0·3646	0·0221	0·1705
Bromide of magnesium . .	0·0052	0·0035	traces
	17·6663	11·8795	6·2942

In some lakes without any outlet, as the Dead Sea and the Lake of Ural, the degree of saltness is considerably augmented. Numerous experiments have proved that the water of the Dead Sea is six times salter than that of the ocean. MM. Boutron and O'Henry analysed, in April, 1850, after the rainy season, some water of the Dead Sea, taken at about two leagues from the mouth of the Jordan; its density was then 1·10.

The saltness of sea water makes it more fitted to float ships, because its density is increased by the salts which are dissolved in it. Besides this, these salts contribute to prevent the water becoming contaminated with decomposed organic matter.

By the table representing the composition of the water of the ocean and that of the Mediterranean, we see that salts of lime and potassium, as well as iodine and silica, are only found in infinitely small quantities. Nevertheless, the lime and silica contained in the sea water are of very great importance; for these quantities, which appear to us so small in the table of a chemical analysis, become enormous in the entire extent of the ocean. The marine plants take up the lime, the silex, the potassium, and the iodides which are dissolved in the sea water, and these mineral substances enter into their textures. It is from the carbonate of lime and silex that the

various marine animals form their solid covering, their shell or carapace; and the Infusoria make use of the lime, silex, and potassium, for the same purpose. It is by knowing all the life-history and habits of the *Cœlenterata* that we explain the appearance of those *Coral Islands* found in the ocean, the existence of which has been a subject of much astonishment, and the history of which shall find a place in another chapter.

The Pacific and Indian Oceans are studded with islands—some in a state of formation—which owe their origin to the coral polyps. These extract from the sea water the lime and silex which are found there in the state of soluble salts. In order to grow and develop, they must be continually under water. They are constantly producing calcareous deposits; these deposits rise rapidly, and at last reach the surface of the water. Then the seaweed and the rubbish of all kinds that the sea carries along with it, arrested by these emerging masses, cover them with a layer of fertile soil, which is soon again covered with vegetation, as the birds and the waves bring seeds thither.

The coral islands of the Pacific, which are described in another chapter, are formed in this manner.

Besides the substances named, sea water also contains, but in infinitesimally small quantities, metals, such as iron, copper, lead, and silver; the old copper collecting round the keels of ships sometimes so much silver that it has been thought worth extracting! A curious calculation has been attempted, based on the age of ships and the distance they have gone during all their voyages, to show that the sea contains in solution 2,000,000 tons of silver.*

The question has often been asked, Whence comes the salt and other substances held in solution in sea water? If our readers will turn back to the first few pages of "The World Before the Deluge," they will better understand the very simple geological explanation that we are going to give of the origin of the different substances dissolved in sea water.

In the first stage of our planet, before the watery vapours contained in the primitive atmosphere were condensed, and before they had begun to fall on the earth in the form of a boiling rain, the shell of the earth contained an infinite variety of heterogeneous mineral substances, some soluble in water, others not. When rain fell on the burning surface for the first time, the waters became charged with all the soluble substances, which were reunited and afterwards

* Sir J. Herschel's "Physical Geography," p. 22, gives the basis and details of this calculation.

deposited, accumulating in the large depressions of the soil. The seas of the primitive globe were thus formed of rain water, holding in solution all that the earth had given up, collected in large basins. Chloride of sodium, sulphates of soda, magnesia, potassium, lime, and silex, this latter in the form of a soluble silicate; in a word, every soluble matter that the primitive globe contained formed part of the mineral contingent of this water. If we reflect that through all time up to the present day none of the general laws of Nature have changed—if we consider that the soluble substances contained in the water of the primitive seas have remained there, and that the fresh water of the rivers constantly replaces the water which disappears by evaporation—we have the true explanation of the saltness of sea water. "It is a very simple theory, it is true," adds M. Figuier, "but one that we have found nowhere, and the responsibility of which we therefore claim. The chloride of sodium is by no means the only substance dissolved in sea water. It contains, besides, many other mineral substances; in short, every *soluble salt* on the face of the globe, and, along with them, portions of different metals in infinitely small quantities."

The mean temperature of the surface of the sea is nearly the same as the atmosphere, so long as no currents of heat or cold interpose their perturbing influence. In the neighbourhood of the Tropics, it appears that the surface of the water is slightly warmer than the ambient air, but experiments on the temperature of the sea from the surface to the bottom reveal, according to our author,* "some evidence which establishes a curious law. In very deep water a perfectly uniform temperature of 4° below zero prevails, which corresponds, as physics have established, to the maximum density of water. Under the Equator this temperature exists at the depth of 7,000 feet. In the Polar regions, where water is colder at the surface, this temperature is maintained at 4,600 feet. The isothermal lines of 4° form a line of demarcation between the zones, where the surface of the sea is colder, and those where it is warmer than the bed of four degrees below zero." This is more clearly shown in Fig. 4, which represents a section of the ocean, the curved line which touches two points at the surface indicating the depths where the temperature is constantly fixed at 4°.

Dr. Maury's account of this phenomenon is asserted with less confidence. The existence of an *isothermal floor* of the ocean, as he calls it, was first suggested by the observations of Kotzebue, Admiral

* "La Terre et les Mers," p. 517, troisième édition.

Beechey, and Sir James C. Ross. "Its temperature, according to Kotzebue, is 36° Fahr., or 4° Centigrade; the depth of this bed, of invariable and uniform temperature, is 1,200 fathoms at the Equator; thence it gradually rises to the parallel of about 56° north and south, when it crops out, and there the temperature of the sea from top to bottom is conjectured to be permanent at 36°. The place of this outcrop, no doubt, shifts with the seasons, vibrating north and south, after the manner of the Calm Belts. Proceeding onwards to the Frigid zones, this aqueous stratum of an unchanging temperature dips again, and continues to incline till it reaches the Poles, at the depth of 750 fathoms; so that on the equatorial side of

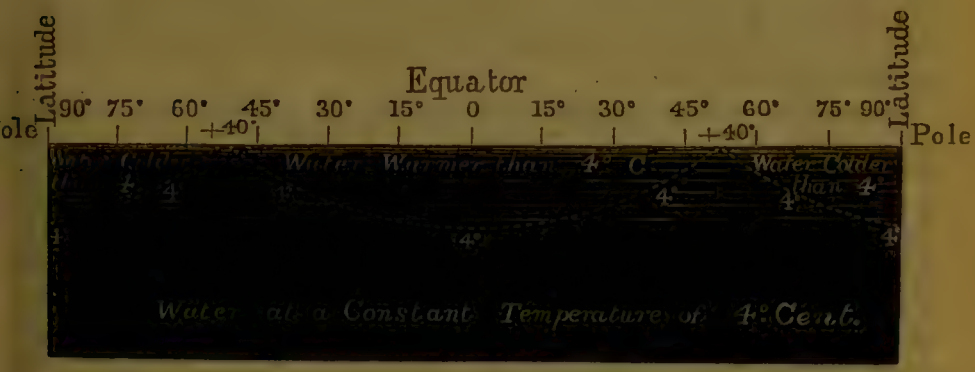


Fig. 4.—Thermal Lines of equal Temperature.

the outcrop the water above the isothermal floor is the warmer, but in Polar seas the supernatant water is the colder."

In the saline properties of sea water Maury discovers one of the principal forces from which currents in the ocean proceed. "The brine of the ocean is the ley of the earth," he says; "from it the sea derives dynamical powers, and its currents their main strength. Hence, to understand the dynamics of the ocean, it is necessary to study the effects of their saltness upon the equilibrium of the waves. Why is the sea made salt? It is the salts of the sea that impart to its waters those curious anomalies in the laws of freezing and of thermal dilatation. It is the salts of the sea that assist the rays of heat to penetrate its bosom." The circulation of the ocean is indispensable to the distribution of temperature—to the maintenance of the meteorological and climatic conditions which rule the development of life; and this circulation could not exist—at least, the

character of its waters would be completely changed—if they were fresh in place of salt. "Let us imagine," says M. Julien, "that the sea, now entirely composed of fresh water, of one uniform temperature from the Pole to the Equator, and from the surface to its greatest depths; the solar heat would penetrate the liquid beds nearest to the Equator; it would dilate them, so as to raise them above their primitive level; by the single effect of gravitation, they would glide on the surface towards the Polar zones. The absence of all solar radiation would tend, on the contrary, to cool and contract them without this tendency. An exchange would be established from the extremities towards the centre; in other words, a counter current of cold and heavy water, calculated to replace the losses occasioned by the action of solar radiation, would descend from the Poles, but quite maintaining itself beneath the light and warm current from the Equator."

In a like system of general circulation, the physical properties of pure water, which attains its maximum of density 7° 2″ F. below zero, would produce the most singular consequences. As its temperature rose above that point, the water would become lighter, having consequently a tendency to ascend towards the upper beds. After this, the equatorial current, meeting in its progress towards the Poles the cold water, would itself be cooled down; and when its temperature had reached 4° below zero, being now heavier than the polar current, would change places with it, descending until it reached water equally dense, while the polar current would ascend. Hence would arise a sort of confusion of currents, which would give to a fresh-water ocean the strangest results, disarranging every instant the regular circulation of its waters. It could not be so, however, in an ocean of salt water, which attains its maximum specific gravity at 4° 8″ below zero. By evaporation at the surface it is concentrated and precipitated, and thus rendered denser than that immediately below the surface. It consequently sinks, while the lower beds come up to replace, in order to modify it, and in turn to be precipitated in the same manner. "In this manner we find established a continually ascending and descending movement, which carries down into the depths of ocean the water warmed at the surface by the solar rays of the Torrid zone. This double vertical current facilitates and prepares the grand horizontal current which puts these submarine reservoirs of heat in communication with the lower beds of the glacial sea. In the Arctic basin the clouds, the melted snow, and the great rivers, which have their mouths on the north of both continents, produce considerable quantities of fresh water, which, mixing

with the waves of the Polar Sea, form a bed of mean density light enough to maintain itself and flow off towards the Atlantic Ocean. These surface movements determine in the lower regions certain contrary movements, whence originate the powerful counter currents which ascend the Straits from Baffin's Bay and reappear in the mysterious 'Polynia' of Kane, diffusing there its treasure of heat brought from intertropical seas." Dr. Kane, in his interesting narrative, reports an open sea north of the parallel of 82°, which he and his party crossed a barrier of ice eighty miles broad to reach, and before he reached it the thermometer marked 60°. Beyond this ice-bound region he found himself on the shores of an iceless sea, extending in an unbroken sheet of water as far as the eye could reach towards the Pole. Its waves were dashing on the beach with the swell of a great ocean; the tides ebbed and flowed. Now the question arises, Where did those tides have their origin? The tidal wave of the Atlantic could not have passed under the icy barrier which De Haven found so firm; therefore they must have been cradled in the cold sea round the Pole; in which case it follows that most, if not all, the unexplored regions about the Pole must be covered with deep water, the only source of strong and regular tides. Seals were sporting, and water-fowl feeding, in this open sea, as Dr. Kane tells us; and the temperature of the water which rolled in and dashed at his feet with measured beat was 36°, while the bottom of the icy barrier of eighty miles was probably hundreds of feet below the surface level.

"The existence of these tides," says Maury, "with the immense flow and drift which annually take place from the Polar Seas and the Atlantic, suggests many conjectures as to the condition of these unexplored regions. Whalers have always been puzzled as to the breeding-place of the great whale. It is a cold-water animal, and, following up the train of thought, the question arises, Is not the nursery for the great whale in this Polar Sea, which is so set about and hemmed in by a hedge of ice, that man may not attempt to trespass there?"

One or two points worthy of notice may be recorded here. Shallow water, and water near the coast, or covering raised sand-banks, is colder than water in the open sea. Alexander von Humboldt explains this phenomenon by supposing that deep waters of higher temperature re-ascend from the lowest depths and mingle with the upper beds. Fogs are frequently formed over sand-banks, because the cold water which covers them produces a local precipitation of atmospheric vapour. The contour of these fogs are perfectly

defined when seen from a distance: they reproduce the form and accidents due to the submarine soil. Moreover, we often see clouds arrested over these points, which look from afar like the peaks of mountains.

CHAPTER II.

CURRENTS OF THE OCEAN.

". . . . . seas that sweep
The three-decker's oaken mast."—TENNYSON.

THE ocean is a scene of unceasing agitation; "its vast surface rises and falls," to use the image suggested by Schleiden, "as if it were gifted with a gentle power of respiration; its movements, gentle or powerful, slow or rapid, are all determined by differences of temperature."

Heat increases its volume and changes the specific gravity of the water, which is dilated or condensed in proportion to the change of temperature. In proportion as it cools, water increases in density, and descends into the depths until it reaches a constant temperature of 4° 25′ Centigrade below zero, which it preserves in all latitudes at the depth of 1,000 yards, according to M. D'Urville.

If the water continues to cool, and reaches zero, it becomes lighter than it was at 4° 25′ Centigrade, and ascends in a state of congelation—a process which, by an admirable provision of Nature, can only take place at the surface. So long as the temperature is above 4° 25′, water is light, and ascends to the surface, while colder water sinks to the bottom. Below 4° 25′ the process is reversed; the first phenomenon is always in force under the Equator, the second near the Poles. The evaporation which is in continual operation in warm seas, forming vast rain-clouds at the expense of the sea, is compensated by unceasing currents of colder water flowing from the Poles. This evaporation has a direct influence, moreover, on the density of sea water, and is pointed out by Dr. Maury as a remarkable instance of the compensations by which the oceanic waters are governed. "According to Rodgers' observations," he says, "the average specific gravity of the sea water on the parallels of 34° north and south, at a mean temperature of 64°, is just what it ought to be, according to saline and thermal laws; but its specific gravity, when taken from the Equator at a mean temperature of

81°, is much greater than, according to the same laws, it ought to be —the observed difference being ·0015, whereas it ought to be ·0025. Let us inquire," he adds, "what makes the equatorial waters so much heavier than they ought to be.

"The anomaly occurs in the trade-wind region, and is best developed between the parallel of 40° in the North Atlantic and the Equator, where the water grows warmer, but not proportionally lighter. The water sucked up by the trade-winds is fresh water, and the salt it contained, being left behind, is just sufficient to counteract by its weight the effect of thermal dilatation upon the specific gravity of water between the parallels of 34° north and south. The thirsting of the trade-winds for vapour is so balanced as to produce perfect compensation; and a more beautiful instance than we have here stumbled upon is not, it appears to me, to be found in the mechanism of the universe."

The oceanic currents are due to a great number of causes: the duration and force of the winds, for instance; the rise and fall of tides all over the globe; the variations in the density of the water, according to its temperature and the evaporating powers of the atmosphere; the depth and degree of saltness to which we have already alluded; finally, to the variations of barometric pressure.

The currents which furrow the ocean often present a striking contrast with the immobility of the neighbouring waters; they may be seen to form rivers of a determinate breadth, whose banks are formed by the water in repose, and whose course is often made quite perceptible by stray floating particles, and often by several aquatic plants which follow in their train.

In order to comprehend the origin of these *pelagic rivers*, it is necessary to consider the laws which govern the atmospheric currents, in particular the *trade winds*. "Hence," says Maury, "in studying the system of oceanic circulation, we set out with the very simple assumption, that from whatever part of the ocean a current is found to run, to that same part a current of equal volume is bound to return; for on this principle is based the whole system of currents and counter currents." The differences of temperature between equinoctial and polar countries generate two opposing currents, the upper one proceeding from the Equator to the Poles, the lower one directed from the Poles towards the Equator. On reaching the Equator, the cold current of air from the Poles is warmed and rarefied, and ascends to the upper beds of the atmosphere, whence it is again led to its point of departure; there it is again cooled, and returns with the lower current towards the tropical regions. But the

rotatory movement of the earth modifies the direction of these atmospheric currents. The movement by which it is carried from west to east being almost nothing at the Poles, but inconceivably rapid under the Equator, it follows that the cold air, in proportion as it advances towards the Tropics, ought to incline a little towards the west. This is just what takes place with these counter currents. The *north-east trade winds*, which prevail in the northern hemisphere, move in a sort of spiral curve, turning to the west as they rush from the Poles to the Equator, and in the opposite direction as they move from the Equator towards the Poles: the immediate cause of this motion being the rotation of the earth on its axis. "The earth," says Dr. Maury, "moves from west to east. Now, if we imagine a particle of atmosphere at the North Pole, where it is *at rest*, to be put in motion in a straight line towards the Equator, we can easily see how this particle of air, coming from the very axis of diurnal rotation, where it did not partake of the diurnal motion, would, in consequence of its own *vis inertiæ*, find as it travelled south that the earth was slipping from under it, as it were, and it would appear to be coming from the north-east and going towards the south-west; in other words, it would be a north-east wind."

In the same manner, the upper currents of air, which proceed towards the Poles with equatorial rapidity, ought to outstrip the atmospheric beds, which are gifted with much smaller rapidity of motion towards the Poles, and turn them towards the east in consequence. These are the south-west and north-west counter trade-winds, which, passing above the *north* and *south-east trades*, often sweep the surface of the sea in the latitudes of the temperate zone. The two *trades* are separated by a belt more or less broad, where the friction experienced at the surface of the sea neutralises their impulse towards the west; in general, the current of air there is an ascending current. This belt, which does not exactly correspond with the Equator, is called the *Zone of Calms*, where atmospheric tempests frequently occur, and the winds make the entire tour of the compass, which has acquired for them the name of *tornadoes*.

The trade-winds, whose movement towards the west is retarded by the friction which the waves of the ocean oppose to them, communicate to these waves, by a sort of reaction, a tendency towards the west, or, to speak more exactly, towards the south-west in the northern hemisphere, and towards the north-west in the opposite hemisphere. The currents on the surface of the water which result from this reaction, reunite under the Equator, and form the *grand equinoctial* current which impels the waters of the east towards the

west. This movement is stronger at the edges than in the middle of the current, because the force which produces it acts there with more energy: it results from this, that the currents bifurcate more readily when any obstacle presents itself to their movement. In the Atlantic Ocean, bifurcation takes place a little to the south of the Equator; the southern branch descends along the coast of Brazil, and probably returns by re-ascending along the west coast of Africa. The northern branch follows the coast of Brazil and Guiana, enters the Sea of the Antilles, and directs its course, reinforced by the current which reaches it from the north-east, into the Bay of Honduras, traverses the Yucatan Channel, and enters the Gulf of Mexico, whence it debouches by the Florida Channel, under the name of the *Gulf Stream*. Of this oceanic marvel Dr. Maury observes that "there is a river in the bosom of the ocean; in the several droughts it never fails, and in the mightiest floods it never overflows; its banks and its bottom are of cold water, while its current is of warm; it takes its rise in the Gulf of Mexico, and empties itself into the Arctic Seas; this mighty river is the Gulf Stream. In no other part of the world is there such a majestic flow of water; its current is more rapid than the Amazon, more impetuous than the Mississippi, and its volume is more than a thousand times greater. Its waters, as far as the Carolina coast, are of indigo blue; they are so distinctly indicated that their line of junction can be marked by the eye." Such is Dr. Maury's description of this powerful current of warm water, which traverses the Atlantic Ocean, and influences in no slight manner the climate of Northern Europe, and especially our own shores.

The Gulf Stream thus described by the American *savant* issues from the Florida Channel, with a breadth of thirty-four miles, and a depth of 2,200 feet, moving at the rate of four and a half miles per hour. The temperature of the water in the vicinity is about 30° Centigrade. From the American coast the current takes a north-east direction towards Spitzbergen, its velocity and volume diminishing as it expands in breadth. Towards 43° of latitude it forms two branches, one of which strikes the coast of Ireland and of Norway, whither it frequently transports seeds of tropical origin; it also warms the frozen waters of the glacial sea. The other branch, inclining towards the south, not far from the Azores, visits the coast of Africa, whence it returns to the Antilles. Throughout this vast circuit may be seen all sorts of plants and driftwood, with waifs and strays of every description borne on the bosom of the ocean. "Midway in the Atlantic, in the triangular space between the Azores, Canaries, and Cape de Verd Islands, is the great Sargassum Sea, covering an

area equal in extent to the Mississippi Valley; it is so thickly matted over with the Gulf Weed (*Sargassum bacciferum*), that the speed of vessels passing through it is actually retarded, and to the companions of Columbus it seemed to mark the limits of navigation; they became alarmed. To the eye at a little distance it seemed sufficiently substantial to walk upon." These moving vegetable masses, always of a brownish green, which tail off to a steady breeze, serving as an anemometer to the mariner, afford an asylum to multitudes of molluscs and crustaceans.

The Gulf Stream plays a grand part in the Atlantic system. It carries the tepid water of the equinoctial regions into the high latitudes; beyond the fortieth parallel the temperature is 16° Centigrade. Urged by the south-west winds which predominate in that zone, its tepid waters mix with those of the Northern Sea, softening the rigour of the climate in these regions. To the south of the great bank of Newfoundland, the warm current, in vast volume, rushing from the Florida Straits meets the cold currents descending from the Arctic Circle through Baffin's Bay and the Sea of Greenland, running with equal velocity towards the south. A portion of these waters re-ascend towards the pole along the western coast of Greenland. It is to this conflict of the polar and equatorial waters, that the formation of the Banks of Newfoundland is ascribed. Each of these great currents having unceasingly deposited the *débris* carried in its bosom, the bank has been thus formed bit by bit in the concourse of ages.

The difference of temperature between the Gulf Stream and the waters it traverses gives birth inevitably to tempests and *cyclones*. In 1780 a terrible storm ravaged the Antilles, in which 20,000 persons perished. The ocean quitted its bed and inundated whole cities; the trunks of trees, mingled with other *débris*, were tossed into the air. Numerous catastrophes of this kind have earned for the Gulf Stream the title of the "King of the Tempests." In consequence of the numerous nautical documents which have been placed at the command of the National Observatory of Washington, and the admirable use made of them by the late Naval Secretary and his assistants, the directions and range of these cyclones engendered by the Gulf Stream may be foreseen, and their most dangerous ravages turned aside. As an example of the utility of Dr. Maury's labours in settling the direction of storms in the *trajet* of the Gulf Stream, we quote a well-known instance: In the month of December, 1859, the American packet *San Francisco* was employed as a transport to convey a regiment to California. It was overtaken by one of these sudden storms, which placed the ship and its freight in a most

dangerous position. A single wave, which swept the deck, tore out the masts, stopped the engines, and washed overboard 129 persons, officers and soldiers. From that moment the unfortunate steamer floated upon the waters, a waif abandoned to the fury of the wind. The day after the disaster the *San Francisco* was seen in this desperate situation by a ship, which reached New York, although unable to assist her. Another ship met her some days after, but, like the other, could render no assistance. When the report reached New York, two steamers were despatched to her assistance; but in what direction were they to go? what part of the ocean were they to explore? The authorities at the Washington Observatory were appealed to. Having consulted his charts as to the direction and limits of the Gulf Stream at that period of the year, Dr. Maury traced on a chart the spot to which the disabled steamer was likely to be driven by the current, and the course to be taken by the vessels sent to her assistance. The crew and passengers of the *San Francisco* were saved before their arrival. Three ships, which had seen their distressing situation, had been able to reach them, and the steamers sent to their assistance only arrived to witness the safety of the passengers and crew. But the point where the steamer foundered shortly after they were transferred to the rescuing ships was precisely that indicated by Dr. Maury. If the ships sent to her assistance had reached in time, the triumph of SCIENCE would have been complete.

The equinoctial currents of the Pacific are very imperfectly known. It is believed, however, that they traverse the great ocean in its whole length, and bifurcate opposite the Asiatic coast, where the weakest branch bends northward until it encounters the polar current from Behring's Straits, when it returns along the Mexican coast. The larger branch inclines towards the south, passing round Australia, where it is met by one or many counter currents coming from the Indian Ocean—of the complicated and dangerous nature of which both Cook and La Peyrouse speak.

The cold waters from the Antarctic Pole are carried towards the Equator by three great oceanic rivers. The first bifurcates in 45°; one portion goes round Cape Horn; the other—Humboldt's current—ascends the Chilian and Peruvian coasts up to the Equator, ameliorating the rainless climate as it goes, and making it delightful. A second great current takes the direction of the African coast, and is divided at the Cape, ascending both the east and west coasts of Africa. On either side of the warm current which escapes from the intertropical parts of the Indian Ocean, but especially along the Australian coast, a polar current wends its way from the Antarctic

regions, carrying supplies of cold water to modify the climate and restore the equilibrium in that part of the world. This cold current turns at first towards the west, then towards the south in the direction of Madagascar; more to the south still it is driven back by the polar current from Cape Horn. It is thus that the warm waters from the Bay of Bengal, pressed by the Indian polar current, circulate between Africa and Australia, one lateral branch of the current sweeping along the south coast of this vast continent. The monsoons which reign in the Indian Ocean tend still more to complicate the currents, already sufficiently intricate and confused.

We have already spoken of a submarine current which appears to carry the waters of the Mediterranean into the Atlantic Ocean. Its existence is in some respects established by calculations which prove that the quantity of salt water supplied by the upper current through the Straits of Gibraltar is equal to seventy-two cubic miles per annum, while the quantity of fresh water brought down by the rivers is equal to six, and the quantity lost by evaporation to twelve cubic miles per annum. This would leave an annual excess of sixty-six cubic miles, if the equilibrium was not re-established by an under current flowing into the Atlantic. This hypothesis would appear to have been confirmed by a very curious fact.

Towards the end of the seventeenth century a Dutch brig, pursued by the French corsair *Phœnix*, was overhauled between Tangier and Tarifa, and seemed to be sunk by a single broadside; but, in place of foundering and going down, the brig, being freighted with a cargo of oil and alcohol, floated between the two currents, and drifting towards the west, finally ran aground, after two or three days, in the neighbourhood of Tangier, more than twelve miles from the spot where she had disappeared under the waves. She had therefore traversed that distance, drawn by the action of the under current in a direction opposite to that of the surface current. This ascertained fact, added to some recent experiments, lends its support to the opinion which admits of the existence of an outward current through the Straits of Gibraltar. Dr. Maury quotes an extract from the "log" of Lieutenant Temple, of the United States Navy, bearing the same inference. At noon on the 8th of March, 1855, the ship *Levant* stood into Almeira Bay, where many ships were waiting for a chance to get westwards. Here he was told that at least a thousand sail were waiting between the bay and Gibraltar, "some of them having got as far as Malaga only to be swept back again. Indeed," he adds, "no vessel had been able to get out into the Atlantic for three months past." Supposing this current to run no faster than two knots an hour, and

assuming its depth to be 400 feet only, and its width seven miles, and that it contained the average proportion of solid matter, estimated at one-thirtieth, it appears that salt enough to make eighty-eight cubic miles of solid matter were carried into the Mediterranean in those ninety days. "Now," continues Dr. Maury, "unless there were some escape for all this solid matter which has been running into this sea, not for ninety days, but for ages, it is very clear that the Mediterranean would long ere this have been a vat of strong brine, or a bed of cubic crystals of salt."

For the same reason, Dr. Maury considers it certain that there is an under current to the south of Cape Horn, which carries into the Pacific Ocean the overflowings of the Atlantic. In fact, the Atlantic is fed unceasingly by the Great American rivers, while the Pacific receives no important affluent, therefore ought to be, and is, subjected to enormous losses, in consequence of the evaporation continually taking place at the surface.

TIDES.

Tides manifest themselves upon our planet by the alternate rising and falling of the waters of the ocean, and by currents also in narrow seas. These effects are produced by two pairs of waves which travel round the earth every day—a greater pair of waves caused by the attraction of the moon, and a smaller pair caused by the sun. The principal pair of waves which form the lunar tide occupy a lunar day, which consists of twenty-four hours and fifty-four minutes in travelling round the earth; while the smaller waves, caused by the sun, take only twenty-four hours to traverse the same distance. It thus sometimes happens that the crests and depressions of the solar and lunar waves coincide. When this occurs we have what are called spring tides, in which, owing to the union of the two waves, the waters advance to their greatest height at the flood, and retreat farthest in the ebb. The spring tides are followed after a certain number of days by neap tides, in which the rising and falling of the water is least. This comes to pass because the solar tide travels quicker round the earth than the lunar tide, and accordingly gains upon it day by day, until in about six or seven days after spring tides the crest of the solar wave has advanced into the depression of the lunar wave, and partly fills it.

By measuring the height of the spring tides, we get a quantity equal to the sum of the heights of the solar and lunar waves, and by measuring the neap tides we get their difference. We may thus learn by observation that the lunar wave is about two and a half times

higher than the solar. It may appear a matter of surprise that the sun, which attracts the earth with a force amazingly more powerful than that exerted by the moon, should produce a feebler tide. But the reason of this will be apparent when the cause of the tides is understood; it will be then seen that it results from the proximity of the moon.

Let us first inquire into the cause of the solar tide. The sun

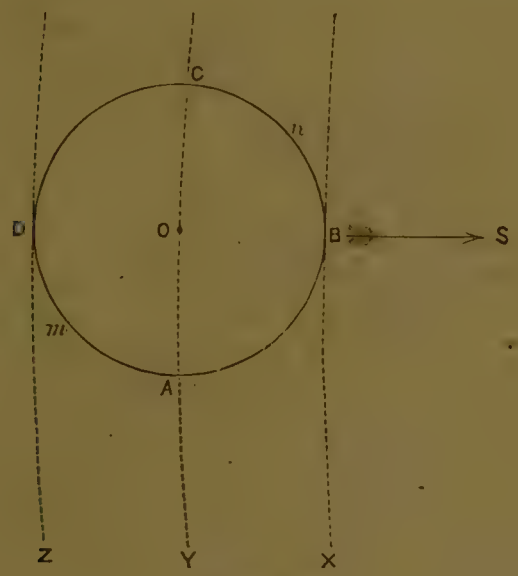


Fig. 5.

attracts the earth with that force which prevents the earth from maintaining a straight course; which bends its path into the vast eclipse that the earth sweeps out round the sun every year. It will be convenient in the first stage of our inquiry to leave out of consideration the daily rotation of the earth on its axis. Let then the dotted lines of the figure (Fig. 5) represent portions of the annual paths which would be pursued by the points O, B, and D, if we suppose that, instead of a daily rotation, B is kept always turned towards the sun. These orbits would be all of them traversed in the same period, viz., a year; and they differ slightly in size, the orbit of which D Z is a portion being the largest, while A X is the smallest, and B Y of intermediate size. Now, when orbits of different sizes are thus

traversed in the same time, the force, directed towards the sun, which must be exerted to effect the necessary bending, is greater the larger the orbit. This is proved in all treatises on mechanics. Hence a greater force in the direction D S is required at D to keep that part of the earth in its orbit than the force acting upon the central parts at O, A, and C; and a less force is sufficient at B. Now, the sun does not supply a force which varies in this way; on the contrary, the sun's attraction is least at D and greatest at B, since the attraction of the sun is a force which decreases with distance. Hence the sun exerts more than a sufficient attraction at B, and less than a sufficient attraction at D, *i.e.*, more and less than would keep those parts of the earth in the orbits which they actually pursue. Hence, at B there is a small surplus of solar attraction, which is not employed in keeping that part of the earth in its path; and as it acts there in the opposite direction to the attraction of the earth, it makes bodies at B less heavy than they would otherwise be. And, again, at D a force somewhat more powerful than the sun's attraction is required to keep this part of the earth in its orbit, and therefore a portion of the force of gravity, *i.e.*, of the attraction towards the centre of the earth, has to assist in this situation and supply the deficiency. This diminishes the weight of bodies at D. The upshot, then, is that at B and D bodies are a little less heavy than they would be in other situations, as at A or C. This defect of weight is very slight, amounting at B and D, where it is greatest, to a loss of not more than one twenty-five-millionth of the whole gravity, but, small as it is, it produces the solar tide. For, keeping still to the supposition of an earth without daily rotation, and supposing further that our imaginary earth is covered everywhere with an ocean, it is evident that water being slightly lighter at B and D than at A and C, there will be an exceedingly feeble tendency to flow from A and C towards B and D, so as to raise protuberances there. The distance from A to B is about 6,200 miles, and as soon as the water has risen about twenty-three inches higher at B and D than at A and C, the tendency to slip back caused by the protuberance is enough to balance the feeble force with which we have to deal. Hence the sun would cause two excessively broad and flat protuberances of the height of twenty-three inches on our imaginary earth.

Let us now take into account the further circumstance that the earth rotates daily on its axis in the direction A B C D. This rotation will carry the protuberance at B towards C. When it is removed from B it will tend to return to its natural station at B, and will take up its position in some situation such as *n*, where its own tendency

to return towards B is equal to the tendency of the earth's rotation to carry it towards C. The crests of the tide will under these circumstances remain at *m* and *n*, while the earth continues to rotate; and of course they will to us, inhabitants of the earth, seem to travel westward, just as the sun and stars seem to travel westward. The solar tide thus assumes the appearance of an immensely broad and excessively flat pair of waves travelling once round the earth from east to west every day.

In the same way the attraction of the moon causes the lunar tide. The moon is so close to the earth—at a distance only 1-400th part of the distance of the sun—that, although the whole force of the moon's attraction is small in comparison with the sun's, there is a more sensible difference in the degree in which a body is attracted by the moon, according as the body is on the side of the earth next the moon or on the farthest side. And by going through the computation, it appears that the moon, on this account, produces a tide about two and a half times the height of the solar tide.

Such is a picture of what would happen if the earth were covered everywhere by a deep ocean. But the phenomena are complicated upon the earth by the obstacle which continents present to the even advance of the tidal waves, and by the modifications which they undergo in shallow or narrow seas, in which they rise to an exaggerated height.

The height of the tide varies in the different regions of the globe according to local circumstances. The eastern coast of Asia and the western coast of Europe are exposed to extremely high tides; while in the South Sea Islands, where they are very regular, they scarcely reach the height of twenty inches. On the western coast of South America, the tides rarely reach three yards; on the western coast of India they reach the height of six or seven; and in the Gulf of Cambay it ranges from five to six fathoms. This great difference makes itself felt in our own and adjoining countries: thus, the tide which at Cherbourg is seven and eight yards high, attains the height of fourteen yards at Saint Malo, while it reaches the height of ten yards at Swansea, at the mouth of the Bristol Channel, increasing to double that height at Chepstow, higher up the river. In general, the tide is higher at the bottom of a gulf than at its mouth.

The highest tide which is known occurs in the Bay of Fundy, which opens up to the south of the isthmus uniting Nova Scotia and New Brunswick. There the tide reaches forty, fifty, and even sixty feet, while it only attains the height of seven or eight in the bay to

the north of the same isthmus. It is related that a ship was cast ashore upon a rock during the night, so high, that at daybreak the crew found themselves and their ship suspended in mid-air far above the water!

In the Mediterranean, which only communicates with the ocean by a narrow channel, the phenomenon of tides is scarcely felt, and from this cause—that the moon acts at the same time upon its whole surface, which is not sufficiently large to increase the swelling mass of waters formed by the moon's attraction; consequently, the swelling remains scarcely perceptible. This is the reason why neither the Black Sea or White Sea presents a tide, and the Mediterranean a very inconsiderable one. Nevertheless, at Alexandria the tide rises twenty inches, and at Venice this height is increased to about four and a half feet. Lake Michigan is slightly affected by the lunar attraction.

Professor Whewell has prepared a map in which the course of the tidal wave is traced in every country of the globe. We see there that it traverses the Atlantic, from 50° of south latitude up to the fiftieth parallel north, at the rate of 560 miles an hour. But the rapidity with which it proceeds is least in shallow water. In the North Sea it travels at the rate of 180 miles. The tidal wave which proceeds round the coast of Scotland traverses the German Ocean and meets in St. George's Channel, between England and Ireland, where the conflict between the two opposing waves presents some very complicated phenomena.

The winds, again, exercise a great influence on the height of the tides. When the impulse of the wind is added to that of the attracting moon, the normal height of the wave is considerably increased. If the wind is contrary, the flux of the tide is almost annihilated. This happens in the Gulf of Vera Cruz, where the tide is only perceptible once in three days, when the wind blows with violence. An analogous phenomenon is observable on the coast of Tasmania.

The rising tide sometimes strikes the shore with a continuous and incredible force. This violent shock is called the *surf*. The swell then forms a billow, which expands to half a mile. The surf increases as it approaches the coast, when it sometimes attains the height of six or seven yards, forming an overhanging mountain of water, which gradually sinks as it rolls over itself. But this motion is not in reality progressive—it transports no floating body. The surf is very strong at the Isle of Fogo, one of the Cape de Verd Islands, in the

Indian Ocean, and at Sumatra, where the surf renders it dangerous and sometimes impossible to land on the coast. Fig. 6 represents the effects of the surf at Point du Raz, on the coast of Brittany. The winds adding their influence to these causes, give birth on the

Fig. 6.—Point du Raz, Coast of Brittany.

surface of the sea to waves or billows, which increase rapidly, rising in foaming mountains, rolling, bounding, and breaking one against the other. "In one moment," says Malte-Brun, "the wave seems to carry sea-goddesses on its breast, which seem to revel in sports and dances; in the next instant, a tempest rising out of them, seems to be animated by its fury. They seem to swell with passion, and

we think we see in them marine monsters which are prepared for war. A strong, constant, and equal wind produces long swelling billows, which, rising on the same line, advance with a uniform movement, one after the other, precipitating themselves upon the coast. Sometimes these billows are suspended by the wind or arrested by some current, thus forming, as it were, a liquid wall. In this position, unhappy is the daring navigator who is subjected to its

Fig. 7.—Height of Waves off the Cape of Good Hope.

fury!" The highest waves are those which prevail in the offing off the Cape of Good Hope at the period of high tide, under the influence of a strong north-west wind, which has traversed the South Atlantic, pressing its waters towards the Cape. "The billows there lift themselves up in long ridges," says Dr. Maury, "with deep hollows between them. They run high and fast, tossing their white caps aloft in the air, looking like the green hills of a rolling prairie capped with snow, and chasing each other in sport. Still, their march is stately, and their roll majestic. Many an Australian-bound trader, after

doubling the Cape, finds herself followed for weeks at a time by these magnificent rolling swells, furiously driven and lashed by the 'brave west winds.' These billows are said to attain the height of thirty, and even forty feet; but no very exact measurement of the height of waves is recorded." One of these mountain waves placed between two ships conceals each of them from the other—an effect which is partially represented in Fig. 7. In rounding Cape Horn, waves are encountered from twenty to thirty feet high; but in the Channel they rarely exceed the height of nine or ten feet, except when they come in contact with some powerful resisting obstacle. Thus, when billows are dashed violently against the Eddystone Lighthouse, the spray goes right over the building, which stands 130 feet above the sea, and falls in torrents on the roof. After the storm of Barbadoes, in 1780, some old guns were found on the shore, which had been thrown up from the bottom of the sea by the force of the tempest.

If the waves, in their reflux, meet with obstacles, whirlpools and whirlwinds are the result—the former the terror of navigators. Such are the whirlpools known in the Straits of Messina, between the rocks of Charybdis and Scylla, celebrated as the terror of ancient mariners, and which were sung by Homer, Ovid, and Virgil:—

> "Scylla latus dextrum, lævum irrequieta Charybdis,
> Infestat; vorat hæc raptis revomitque carinas.
> * * * * * * *
> Incidit in Scyllam, cupiens vitare Charybdim."

These rocks are better understood and less feared in our days. At Charybdis there is a foaming whirlpool; at Scylla the waves dash against the low wall of rock which forms the promontory, and are scarcely noticed by the navigator of our days.

Another celebrated whirlpool is that of Euripus, near the Island of Eubœa; another is known in the Gulf of Bothnia. But perhaps the best known whirlpool is the Maelström, whose waters have a gyratory movement, producing a whirlpool at certain states of the tide, the result of opposing currents, which change every six hours, and which, from its power and magnitude, was at one time thought capable of attracting and engulfing ships to their destruction, although it is now known not to be dangerous even to very small craft.

To the combined effects of tides and cyclones may also be attributed the hurricanes, so dreaded by navigators, which so frequently visit the Mauritius and other parts of the Indian Ocean. In periods of the utmost calm, when there is scarcely a breath to ruffle the air, these shores are sometimes visited by immense waves, accompanied

by whirlwinds, which seem capable of blowing the ships out of the water, seizing them by the keel, whirling them round on an axis, and finally capsizing them. "At the period of the changing monsoon, the winds, breaking loose from their controlling forces, seem to rage with a fury capable of breaking up the very foundations of the deep."

The hurricanes of the Atlantic occur in the months of August and September, while the south-west monsoon of Africa and the south-east monsoon of the West Indies are at their height; the agents of the one drawing the north-east trade-winds into the interior of Mexico and Texas, the other drawing them into the interior of Africa, greatly disturbing the equilibrium of the atmosphere.

The Arctic Regions.

The extreme columns of the known world are Mount Parry, situated at eight degrees from the North Pole, and Mount Ross, twelve degrees from the South Pole. Beyond these limits our maps tell us nothing; a blank space marks each extremity of the terrestrial axis. Will man ever succeed in passing these icy barriers? Will he ever justify the prediction of the poet Seneca, who tells us that "the time will come in the distant future when Ocean will relax her hold on the world, when the immense earth will be open, when Tethys will appear amid new orbs, and where Thule (Iceland) shall no longer be the extreme limit of the earth?"

> "Venient annis
> Sæcula seris quibus oceanus
> Vincula rerum laxet et ingens
> Pateat tellus, Tethysque novos
> Detegat orbes, nec sit terris
> Ultime Thule."

No one can say. Every step we have taken in order to approach the North Pole has been dearly purchased; and it is not without reason that navigators have named the south point of Greenland Cape Farewell. Of the number of expeditions, for the most part English, which have been fitted out, at the cost of nearly a million sterling, to explore the Frozen Ocean, one-twentieth have had for their mission to ascertain the fate of the lamented Sir John Franklin.

Scandinavian traditions attribute the first attempts to penetrate the Arctic circle to the son of the King Rodian, who lived in the seventh century; to Osher, the Norwegian, in 873; and to the Princes Harold and Magnus, in 1150; but the first navigator in

historic times who penetrated to Arctic polar regions was Sebastian Cabot, who, in 1498, sought a north-west passage from Europe to China and the Indies. Considering the date, and the state of navigation at that period, this was perhaps the boldest attempt on record.

Sebastian Cabot reached as high as Hudson's Bay, but a mutiny of his sailors forced him to retrace his steps. In 1500, Gaspard de Cortereal discovered Labrador; in 1553, Sir Hugh Willoughby Nova Zembla, and Chancellor the White Sea about the same time. Davis visited in 1585 the west coast of Greenland, and two years later he discovered the strait which bears his name. In 1596 Barentz discovered Spitzbergen, which was again seen by Hendrich Hudson, who sailed up to and beyond the eighty-second parallel. Three years later Hudson gave his name to the great Labrador Bay, but he could get no farther. His crew revolted, and he was left in the ship's launch with his son, seven sailors, and the carpenter, who remained faithful; one by one they died, and thus perished one of our greatest navigators.

The Island of Jan Mayen was discovered in 1611; the channel which Baffin took for a bay, and which bears his name, was discovered in 1616. Behring discovered, in his first voyage in 1727, the strait which separates Siberia from America; he sailed through it in 1741, but his ship was stranded, and he himself died of scorbutic disease.

In the year 1771 the Polar Sea was discovered by Hearne, a fur merchant; it was explored long after by Mackenzie.

From the year 1810, when Sir John Ross, Franklin, and Parry, turned their attention to the Arctic regions, expeditions to the Polar Seas rapidly succeeded each other.

In his first voyage, made in 1818, Sir John Ross was led to think that Lancaster Sound was closed by a chain of mountains, which he called the Croker Mountains; but in the following year Captain Parry, in command of two ships, the *Hecla* and *Griper*, discovered that this was an error. This celebrated navigator discovered Barrow's Straits, Wellington Channel, and Prince Regent Inlet, Cornwallis, Sir Byam Martin, and Melville Islands, to which the name of Parry's Archipelago has been given. In this short voyage he gathered more new results than were obtained by his successors during the next forty years. He was the first to traverse these seas. Upon Sir Byam Martin Island he discovered and described the ruins of some ancient habitations of the Esquimaux. He passed the winter on Melville Island. In order to attain his chosen anchorage in Winter's

Bay, he was compelled to saw a passage in the ice of a league in length, which involved the labour of three days; but scarcely were they moored in their chosen harbour than the thermometer fell to 18° below zero. They carried ashore the ship's boats, the cables, the sails, and log-books. The masts were struck to the maintop; the rest of the rigging served to form a roof, sloping to the gunwale, with a thick covering of sail-cloth, which formed an admirable shelter from the wind and snow. Numberless precautions were taken against cold and wet under the decks. Stoves and other contrivances maintained a supportable degree of temperature. In each dormitory a false ceiling of impermeable cloth interposed to prevent the collection of moisture on the wooden walls of the ship. The crew were divided into companies, each company being under the charge of an officer, charged with the daily inspection of their clothes and cleanliness—an essential protection against scurvy. As a measure of precaution, Captain Parry reduced by one-third the ordinary ration of bread; beer and wine were substituted for spirits; and citron and lime-juice were served out daily to the sailors. Game was sometimes substituted, to vary a repast worthy of Spartans. As a remedy against *ennui*, a theatre was fitted up, and comedies acted, for which occasions Parry himself composed a vaudeville, entitled "The North-West Passage; or, the End of the Voyage." During this long night of eighty-four days, the thermometer in the saloons marked 28°, and outside 35°, below zero, and for a few minutes actually reached 47°. Some of the sailors had their noses, fingers, and toes frozen, from the effects of which they never quite recovered. One day the hut which served as an observatory was discovered to be on fire; a sailor who saved one of the precious instruments lost his hands in the effort; they were completely frost-bitten in the attempt.

Nevertheless, the month of June arrived, and with it the opportunity of making excursions in the neighbourhood. It was found that in Melville Island the earth was carpeted with moss and herbage, with saxifrages and poppies. Hares, reindeer, the musk-ox, northern geese, plovers, white wolves and foxes, began to roam around their haunts, disputing their booty with the crew. Captain Parry could not risk a second winter in this terrible region, but returned home as soon as the thaw left the passage open.

In 1821 Captain Parry undertook a second voyage with the *Fury* and *Hecla*. He visited Hudson's Bay and Fox's Channel. In his third voyage, undertaken in 1824, he was surprised by the frost in Prince Regent's Channel, and was constrained to pass the winter

there. The *Fury* was dismantled, and, being found unfit for service, Captain Parry was obliged to abandon her and return to England.

Accompanied by Sir James Ross, Parry again put to sea in the *Hecla*, in April, 1826. On this, his third voyage, on leaving Table Island on the north of Spitzbergen, Parry placed his crew in the two training ships, *Enterprise* and *Endeavour;* the first under his own command, the second under the orders of Sir James Ross. Sometimes they sailed, sometimes they were hauled through the crust of the ice; sometimes the ice, which pierced their shoes, showed itself bristling with points, and was split up into valleys and little hills, which it was difficult to scale. In spite of the courage and energy of their crews, the two ships scarcely advanced four miles a day, while the drifting of the ice towards the south led them imperceptibly towards their point of departure. They reached latitude 82° 45′ 15″, however, and this was the extreme point which they attained.

In the month of May, 1829, Sir John Ross, accompanied by his nephew, James Clark Ross, again turned towards the Polar Seas. He entered Prince Regent's Channel, and there he found the *Fury*, which had been dismantled and abandoned by Parry in these regions eight years before. The provisions which the old ship still contained were quite a providential resource to Ross's crews. The distinguished navigator explored the Boothian Peninsula, and passed four years consecutively in Port Felix, without being able to disengage his vessel, the *Victory*, from the ice. This gave him ample leisure to become familiar with the Esquimaux. Sir John Ross, in his account of this long sojourn in polar countries, has recorded many conversations with the natives, which our space does not permit us to quote. From this terrible position, bound in by the ice, he was at last extricated, and emerged with his crew from this icy prison, when all hope of his return had been abandoned. After being exposed to a thousand dangers, Ross and his crew were at last observed, after many efforts on their parts to attract attention, by a whaling ship, which received them on board. On learning that the ship which had saved them was the *Isabella*, formerly commanded by Captain Ross, he made himself known. "But Captain Ross has been dead two years," was the reply.

We need not repeat here the enthusiastic reception Sir John Ross and his companions met with on their arrival in London.

During an excursion made by the nephew of the Commander (afterwards Sir James Clark Ross), he very closely approached the North Magnetic Pole. This was at eight o'clock on the morning of the 1st of June, 1831, and on the west coast of Boothia. The dip of

the magnetic needle was nearly vertical, being 89° 59″—one minute short of 90°. The site was a low flat shore, rising into ridges from fifty to sixty feet high, and about a mile inland.

Contrary to the judgment of many officers of experience in polar explorations, the last and most fatal of all the expeditions was undertaken by Sir John Franklin, with 137 picked officers and men, in the ships *Erebus* and *Terror*. The adventurers left Sheerness on the 26th of May, 1846, the ships having been strengthened in every conceivable way, and found in everything calculated to secure the safety of the expedition. On the 22nd of July the ships were spoken by the whaler *Enterprise*, and, four days later, they were sighted by the *Prince of Wales*, of Hull, moored to an iceberg, waiting an opening to enter Lancaster Sound. There the veil drops over the ships and their unhappy crews. In 1848 their fate began to excite a lively interest in the public mind. Expedition in search of them succeeded expedition, at immense cost, sent both by the English and American authorities, and one by Lady Franklin herself, some of which penetrated the Polar Seas through Behring's Straits, while the majority took Baffin's Bay. In 1850, Captains Ommaney and Penny discovered, at the opening of Wellington Channel, some vestiges of Franklin, which led to another expedition in 1857, which was got up by private enterprise, and of which Captain Sir Leopold M'Clintock had the command. Guided by the indications collected in the previous expedition, and by intelligence gathered from the Esquimaux by Dr. Rae in his land expedition, Captain M'Clintock, in the yacht *Fox*, discovered, on the 6th of May, 1859, upon the north point of King William's Land, a cairn or heap of stones. Several leaves of parchment, which were buried under the stones, bearing date the 28th of May, 1848, solved the fatal enigma. The first, dated the 24th of May, 1847, gave some details, ending with "all well;" but the papers had been dug up twelve months later to record the death of Franklin, on the 11th of June, 1847. The survivors are supposed to have been at this time on their way to the mouth of the River Back; but they must have sunk under the terrible hardships to which they were exposed, in addition to cold and hunger.

In September, 1859, Captain M'Clintock returned to England, bringing with him many relics of our lost countrymen, found in the country of their misfortunes.

To go back to the period between 1848 and this latter period. After the return of Captain M'Clintock, in 1850, Captain Sir R. M'Clure, leaving Behring's Straits, discovered the north-west passage

between Melville and Baring's Islands, which passage had been sought for without success during so many ages. He saw the thermometer descend 50° below zero. In the month of October, 1854, he returned to England, and, at a subsequent period, it was ascertained with certainty that, before his death, Franklin knew of the other passage which exists to the north of America, to the south of Victoria Land and Wollaston.

The expedition of Dr. Kane entered Smith's Strait in 1853, and advanced towards the north upon sledges drawn by dogs; the mean temperature, which ranged between 30° and 40° below zero, fell at last to 50°. At 11° from the Pole they found two Esquimaux villages, called Etah and Peterovik. A detachment, conducted by Lieutenant Morton, discovered, beyond 80° of latitude, an open channel inhabited by innumerable swarms of birds, consisting of sea swallows, ducks, and gulls, which delighted them by their shrill, piercing cries. Seals enjoyed themselves on the floating ice. In ascending the banks they met with flowering plants belonging to such genera as *Lychnis*, *Hesperis*, &c. On the 24th of June, Morton hoisted the flag of the *Antarctic*, which had before this seen the ice of the South Pole on Cape Independence, situated beyond 81°. To the north stretched an open sea. On the left was the western bank of the Kennedy Channel, which seemed to terminate in a chain of mountains, the principal peak rising from 9,000 to 10,000 feet, which was named Mount Parry. The expedition returned towards the south, and reached the port of Uppernavick exhausted with hunger, where it was received on board an American ship. Dr. Kane, weakened by his sufferings, from which he never quite recovered, died in 1857.

We cannot conclude this rapid sketch of events connected with the expeditions to the Arctic Pole without noting a geological fact of great and singular interest. When opportunities have presented themselves of examining the rocks in the regions adjoining the North Pole, it has been found that many of them belong to the coal measures. Such is the case in Melville Island and Prince Patrick's Island. Under the ice which covers the soil in these islands coal exists, with all the fossil plants which invariably accompany it. This shows that in the coal period of geology, the North Pole was covered with a rich and abundant vegetation whose remains constitute the coal-fields of the present day; and proves to demonstration that the temperature of these regions was, at one period of the earth's history, equal to that of the more temperate regions of the present day. What a wonderful change in the temperature of these regions is thus indicated! It is, indeed, a strange contrast to find coal formations

under the soil covered by the polar ice. Strange would it be if human industry should dream of establishing itself in these countries, and drawing from the earth the combustible material so needed to make it habitable, thus furnishing the means of overcoming the rigorous climatic conditions of these inhospitable regions!

The Antarctic Regions.

The Antarctic Pole is probably surrounded by an icy canopy not less than 2,500 miles in diameter; and numerous circumstances seem to lead to the conclusion that the vast mass has somewhat diminished since 1774, when the region was visited by Captain Cook. The Antarctic region can only be approached during its summer season, namely, in December, January, and February.

The first navigator who penetrated the Antarctic circle was the Dutch captain, Theodoric de Gheritk, whose vessel formed part of the squadron commanded by Simon de Cordes, destined for the East Indies. In January, 1600, a tempest having dispersed the squadron, Captain Gheritk was driven as far south as the sixty-fourth parallel, where he observed a coast which reminded him of Norway. It was mountainous, covered with snow, stretching from the coast to the Isles of Solomon. The report of Simon de Cordes was received with great incredulity, and the doubts raised were only dissipated when the New South Shetland Islands were definitely recognised. The idea of an Antarctic continent is, however, one of the oldest conceptions of speculative geography, and one which mariners and philosophers alike have found it most difficult to relinquish. The existence of a southern continent seemed to them to be the necessary counterpoise to the Arctic land. The *terra Australis incognita* is marked on all the maps of Mercator round the South Pole, and when the Dutch officer, Kerguelen, discovered, in 1772, the island which bears his name, he quoted this idea of Mercator as the motive which suggested the voyage. In 1774, Captain Cook ventured up to and beyond 71° of latitude under 109° west longitude. He traversed 180 leagues, between 50° and 60° of south latitude without finding the land of which mariners had spoken; this led him to conclude that mountains of ice, or the great fog-banks of the region, had been mistaken for a continent. Nevertheless, Cook himself clung to the idea of the existence of a southern continent. "I firmly believe," he says, "that near the South Pole there is land, where most part of the ice is formed which is spread over the vast Southern Ocean. I cannot believe that the ice could extend itself so far if it had not land—and

I venture to say land of considerable extent—to the south. I believe, nevertheless, that the greater part of this southern continent ought to lie within the Polar Circle, where the sea is so encumbered with ice as to be unapproachable. The danger run in surveying a coast in these unknown seas is so great, that I dare say no one will venture to go farther than I have, and that the land that lies to the south will always remain unknown. The fogs are there too dense; the snow-storms and tempests too frequent; the cold too severe; all the dangers of navigation too numerous. The appearance of the coast is the most horrible that can be imagined. The country is condemned by Nature to remain unvisited by the sun, and buried under eternal hoar frost. After this report, I believe that we shall hear no more of searches for a southern continent." This description of these desolate regions, to which the great navigator might have applied the words of Pliny, "Pars mundi a natura damnata et densa mersa caligine," only excited the courage of his successors. In our days, several expeditions have been fitted out for the express survey of regions which may be characterised as the abode of cold, silence, and death. In 1833 a free passage opened itself into the Antarctic Sea. A Scottish whaling ship, commanded by James Weddell, entered the pack ice, and penetrated it in pursuit of seals; but having, by chance, found the sea open on his course, he forced his way up to 74° south latitude, and under 34° of longitude; but the season was too advanced for further investigation, and he and his crew retraced their steps. The voyage of Captain Weddell caused a great sensation, and suggested the possibility of more serious expeditions. Twelve years later three great expeditions were fitted out: one, under Dumont D'Urville, of the French Marine; an American expedition, under Captain Wilkes, of the United States Navy; and an English expedition, under Sir James Clark Ross.

Dumont D'Urville, who perished so miserably in the railway catastrophe at Versailles in 1842, passed the Straits of Magellan on the 9th of January, 1838, having under his command the two corvettes *Astrolabe* and *Zelée*. He expected to find it as Weddell had described, and that, after passing the first icy barrier, he should find an open sea before him. But he was soon compelled to renounce this hope. The floating icebergs became more and more closely packed and dangerous. The southern icebergs do not appear to circulate in straits and channels already formed, like those of the North Pole, but form enormous detached blocks which hug the land. Sometimes in shallow water they form belts parallel to the base of the cliffs, intersected by a small number of sinuous narrow channels.

These icy cliffs present a face more or less disintegrated as they approach to the rocky shore. The blocks of ice form at first huge prisms, or tabular regular masses; but they get broken up by degrees, and rounded off and separated under the action of the waves, which chafe them, and their colour becomes more and more limpid and bluish. They ascend freely towards the north, often in spite of the winds and currents which tend to carry them in the contrary direction. One year with another these floating icebergs accumulate with very striking differences, and it is only by a rare chance that they open up a free passage such as Captain Weddell had discovered. These floating islands of ice have been met with in 35° south latitude, and even as high as Cape Horn.

The two French ships frequently found themselves shut up in the icebergs, which continued to press upon them while driven before the north winds, then the south wind would again disperse their vast masses, enabling the ships to issue from their prison all safe and sound. In some cases D'Urville found it necessary to force his ships through fields of ice by which he was surrounded and imprisoned, and to cut his way by force through the accumulating blocks, using the corvette as a sort of battering ram. In 1838 he recognised, about fifty leagues from the South Orkney Isles, a coast, to which he gave the name of *Louis Philippe's* and *Joinville's Land.* This coast is covered with enormous masses of ice, which seemed to rise to the height of 2,600 feet. The crew of D'Urville's ship being sickly and overworked, he returned to the port of Chili, whence he again issued for the South Pole in the following January.

On this occasion his approach was made from a point diametrically opposite to his former attempt. He very soon found himself in the middle of the ice. He discovered within the Antarctic Circle land, to which he gave the name of *Adelia's Land.* The long and lofty cliffs of this island or continent he describes as being surrounded by a belt of islands of ice at once numerous and threatening. D'Urville did not hesitate to navigate his corvettes through the middle of the band of enormous icebergs which seemed to guard the Pole and forbid his approach to it. For some time his vessels were so surrounded that they had reason to fear, from moment to moment, some terrible shock, some irreparable disaster. In addition to this, the sea produces around these floating icebergs, eddies, which were not unlikely to draw on the ship to the destruction with which it was threatened at every instant. It was in passing at their base that D'Urville was able to judge of the height of these icy cliffs. "The walls of these blocks of ice," he says, "far exceeded our masts and

rigging in height; they overhung our ships, whose dimensions seemed ridiculously curtailed. We seem to be traversing the narrow streets of some city of giants. At the foot of these gigantic mountains we perceived vast caverns hollowed by the waves, which were engulfed there with a crashing tumult. The sun darted his oblique rays upon the immense walls of ice, making them look as if they were crystal, and presenting effects of light and shade truly magical and startling. From the summit of these mountains, numerous brooks, fed by the melting ice produced by the summer heat of a January sun in these regions, threw themselves in cascades into the icy sea. Occasionally these icebergs would approach each other so as to conceal the land entirely, and we could only perceive two walls of threatening ice, whose sonorous echoes sent back the word of command of the officers. The corvette which followed the *Astrolabe* appeared so small, and its masts so slender, that the ship's crew were seized with terror. For nearly an hour we only saw vertical walls of ice."

Ultimately they reached a vast basin, formed on one side by the chain of floating islands which they had traversed and on the other by high land rising 3,000 and 4,000 feet, rugged and undulating on the surface, but clothed all over with an icy mantle which was rendered dazzlingly imposing in its whiteness by the rays of the sun. The officers could only advance by means of the ship's boats through a labyrinth of icebergs up to a little islet lying opposite to the coast. They landed on this islet; the French flag was planted, possession was taken of the new territory, and, in proof of possession, some portions of rock were torn from the scarped and denuded cliffs. These rocks were found to be composed of quartz and gneiss. The southern continent, therefore, apparently belongs to the primitive formation, while the northern region belongs in great part to the carboniferous period. According to D'Urville, who surveyed the region of Adelia's Land over an extent of thirty leagues of country, the region is one of death and desolation, without any trace of vegetation.

A little more to the south the French navigator had a vague vision of the white outlines of the horizon of another land, which he named *Côte Claire*, or Coast Clear, the existence of which was soon afterwards confirmed by the American expedition under Commodore Wilkes. This officer has explored the southern land on a larger scale than any other navigator; but he suffered himself to be led into error by the dense fogs of the region, and has laid down coast lines on his map where Sir James Ross subsequently found only open

sea—an error which has very unjustly thrown discredit on the whole expedition.

The English expedition, under Sir J. C. Ross, entered this region on Christmas Day, 1840, which was passed by Ross in a strong gale, with constant snow or rain. Soon after, the first icebergs were seen, having flat tubular summits, and being in some instances two miles in circumference; they were bounded on all sides by perpendicular cliffs of ice. On New Year's Day, 1841, the ships crossed the Antarctic Circle, and reached the edge of the pack ice, which they entered, after skirting it for several days. On the 5th the pack was passed through, amid blinding snow and thick fog, which on clearing away revealed an open sea; and on the 11th of January land was seen directly ahead of the ships. A coast line rose in lofty snow-covered peaks at a great distance. On a nearer view, this coast is thus described:—"It was a beautifully clear evening, and two magnificent ranges of mountains rose to elevations varying from 7,000 to 10,000 feet above the level of the sea. The glaciers which filled their intervening valleys, and which descended from near the mountain summits, projected in many places several miles into the sea, and terminated in lofty perpendicular cliffs. In a few places the rocks broke through their icy covering, by which alone we could be assured that masses of lava formed the nucleus of this, to all appearance, enormous iceberg. This antarctic land was named Victoria Land, in honour of the Queen of England. It was coasted up to 78° south latitude, and near to this a magnificent volcanic mountain presented itself, rising 12,000 feet above the level of the sea, which emitted flame and smoke in great quantities. The flanks of this gigantic mountain were clothed with snow almost to the mouth of the very crater from which the flame and smoke issued. At a short distance, Ross discovered the cone of an extinct, or, at least, inactive volcano. He gave to these two volcanoes the names of his vessels, *Erebus* and *Terror* (Fig. 8)—names perfectly in harmony with the surrounding desolation. The ice-covered cliffs rose about 190 feet high, and appeared to be about 300 feet deep; soundings were found at about 400 fathoms. In the distance, towards the south, a range of lofty mountains was observed, which Ross named *Mount Parry*, in honour of his old commander. When Ross commenced to retrace his steps, the expedition had advanced as far as 79° of south latitude.

It may be said of the polar countries that they form a transition state between land and sea, for water is always present, although in a

solid state; the surface is always at a very low temperature; snow does not melt as it falls, and the sea is thus sometimes covered with a continuous sheet of frozen snow; sometimes with enormous floating blocks of ice which are driven by the currents. Meeting with these floating masses of ice is one of the dangers of polar navigation. Captain Scoresby has given a very detailed description of the different

Fig. 8.—Mounts Erebus and Terror.

kinds of ice met with in the Arctic Seas. The ice-fields of this writer are extensive masses of solid water, of which the eye often cannot trace the limits; some of them have been met with thirty-five leagues in length and ten broad, with a thickness of from seven to eight fathoms; but generally these ice-fields rise only four to six feet above the water, and reach from three to four fathoms beneath its surface. Scoresby has seen these ice-fields forming in the open sea. When the first crystals appear, the surface of the ocean is cold enough to

prevent snow from melting as it falls. On the approach of congelation the surface solidifies, and seems as if covered with oil; small circles are formed, which press against each other, and are finally soldered together until they form a vast field of ice, the thickness of which increases from the lower surface.

The water produced from melted ice is perfectly fresh—the result of a well-known physical cause. When a saline solution like sea-water is congealed by cold, pure water alone passes into the solid state, the saline solution becomes more concentrated, increases in density, and sinks to the bottom. Blocks of ice, therefore, in the Polar Seas, are always available for use. There are, however, salt blocks of ice, which are distinguished from fresh-water ice by their opaqueness and their dazzling white colour—their saltness is due to the sea-water retained in their interstices.

The ice-fields, which are formed in high latitudes, are driven towards the south both by winds and currents; but sooner or later the action of the waves breaks them up into fragments. The edges of the broken icebergs are thus often rising and continually changing. These asperities and protuberances are called *hummocks* by English navigators; they give to the polar ice an odd, irregular appearance. Hummocks form themselves of the stray, broken icebergs which come in contact with each other at their edges, and thus form vast rafts, the pieces of which may exceed 100 yards in length.

When these icebergs are separated by open spaces, through which vessels can be navigated, the pack ice is said to be open; but it often happens that mountains of ice occur partly submerged, where one edge is retained under the principal mass, while the other is above the water. Scoresby once passed over a *calf*, as English mariners call these icy mountains; but he trembled while he did so, dreading lest it should throw his vessel, himself, and crew into the air before he could pass it. The aspect of the ice-fields varies in a thousand ways. Here one forms an incoherent chaos resembling some volcanic district, with crevices in all directions, bristling with unshapely blocks piled up at random; there it is a strongly-marked plain, an immense mosaic formed of vast blocks of ice of every age and thickness, the divisions of which are marked by long ridges of the most irregular forms; sometimes resembling walls composed of great rectangular blocks, sometimes resembling chains of hills, with great rounded summits.

In the spring, when a thaw sets in, and the fields begin to break up, the pieces of light ice which unite the great blocks into single masses are the first to melt; the several blocks then separate, and

the motion of the water soon disperses them, and the ships imprisoned by them find a free passage. But a day of calm is still sufficient to unite the dispersed masses, which oscillate and grind against each other with a strange noise, which sailors compare to the yelping of young dogs.

When a ship is shut up in one of these floating ice-fields, inexplicable changes sometimes occur amid their vast incoherent aggregations. Vessels which appear to their crew immovable are found in a few hours to have completely reversed their positions. Two ships shut in at a short distance from each other were driven many leagues asunder without being able to perceive any change in the surrounding ice. At other times ships are drawn along with the floating ice-fields, just as the white bears are who make long voyages at sea upon these monster vehicles. In 1777 the Dutch vessel the *Wilhelmina* was carried along with some other whaling ships from 80° north back to 62°, in sight of the Iceland coast. During this terrible journey the ships were broken up one after the other. More than 200 persons perished, and the remainder at last reached land with difficulty.

Lieutenant De Haven, navigating in search of Sir John Franklin, was caught in the ice in the middle of the channel in Wellington Strait. During the nine months which he remained in captivity, he drifted nearly 1,300 miles towards the south; and the ship *Resolute*, abandoned by Captain Kellet in an ice-field of immense extent, was drifted towards the south with this vast mass to a much greater distance.

Some curious speculations are hazarded by Dr. Maury, arising out of some investigations of his upon the winds and currents, some facts seeming to indicate the existence of a climate, mild by comparison, within the Antarctic Circle. These indications are a low barometer, a high degree of aërial rarefaction, and strong winds from the north. "The winds," he says, "were the first to whisper of this strange state of things, and to intimate to us that the Antarctic climates are in winter very unlike the Arctic for rigour and severity." The result of an immense mass of observation on the polar and equatorial winds reveals a marked difference in atmospherical movements north, as compared with the same movements south, of the Equator; the equatorial winds of the northern hemisphere being only in excess between the tenth and thirteenth parallels, while those of the southern hemisphere are dominant over a zone of 45°, or from 35° south to 10° north.

"The fact that the influence of the polar indraught upon the winds should extend from the Antarctic to the parallel of 40° south,

while that from the Arctic is so feeble as scarcely to be felt in 50° north, is indication enough as to the difference in degree of aërial rarefaction over the two regions. The significance of the fact is enhanced by the consideration that the 'brave west winds,' which are bound to the place of greatest rarefaction, rush more violently and constantly along to their destination than do the counter trades of the northern hemisphere. Why should these polar-bound winds differ so much in strength and prevalence, unless there be a much more abundant supply of caloric, and, consequently, a higher degree of rarefaction, at one pole than at the other?"

That this is the case is confirmed by all the known barometrical observations, which are very much lower in the Antarctic than in the Arctic, and Dr. Maury thinks this is doubtless due to the excess in the Antarctic regions of aqueous vapour and of latent heat.

"There is," he writes, "rarefaction in the Arctic regions. The winds show it, the barometer attests it, and the fact is consistent with the Russian theory of a Polynia in polar waters. Within the Antarctic Circle, on the contrary, the winds bring air which has come over the water for the distance of hundreds of leagues all around; consequently, a large portion of atmospheric air is driven away from the austral regions by the force of vapour."

CHAPTER III.

LIFE IN THE OCEAN.

"See what a lovely shell,
Small and pure as a pearl,
Frail, but a work divine,
Made so fairly well,
With delicate spire and whorl,
A miracle of design."

TENNYSON.

"THE appearance of the open sea," says Frédol, from whose work this chapter is chiefly compiled, "far from the shore—the boundless ocean—is to the man who loves to create a world of his own, in which he can freely exercise his thoughts, filled with sublime ideas of the Infinite. His searching eye rests upon the far-distant horizon. He sees there the ocean and the heavens meeting in a vapoury outline, where the stars ascend and descend, appear and disappear in their turn. Presently this everlasting change in Nature awakens in him a vague feeling of that sadness 'which,' says Humboldt, 'lies at the root of all our heartfelt joys.'"

Emotions of another kind are produced by the contemplation and study of the habits of the innumerable organised beings which inhabit this great deep. In fact, that immense expanse of water, which we call the sea, is no vast liquid desert; life dwells in its bosom as it does on that of the dry land. Here this mystery of life reigns supreme. It is among the most beautiful, the most noble, and the most incomprehensible of His manifestations. Without life, the world would be as nothing. All the beings endowed with it transmit it faithfully to other beings, they again to their successors, which will be, like them, the depositaries of the same mysterious gift; the marvellous heritage thus traverses years and hundreds of years without losing its powers; the globe is teeming with the life which has been so bounteously distributed over it.

In every living being there are two powers, between which a

silent but incessant combat is being carried on—*life*, which builds up, and *death*, which pulls asunder. At first, life is all powerful—it lords it over matter; but its reign is limited. Beyond a certain point its physical vigour becomes gradually impaired; with old age it feebly struggles; and it is finally extinguished with time, when the chemical and physical laws seize upon it, and its organisation is destroyed. But in turn the very elements, though inert at first, are soon reanimated and occupied with a new life. Every plant, every animal is bound up with the past, and is part of the future, for every generation which starts into life is only the corollary upon that which expires, and the prelude of another which is about to be born. Life is the school of death; death is the foster-mother of life.

Life, however, does not always exhibit itself at the actual moment of its formation. It is visible later, and only after other phenomena. In order to develop itself a suitable medium must be prepared, and other determinate physical and chemical conditions provided. The presence and diffusion of living beings are by no means due to chance; they follow rigorously an order of law. Speaking of the higher forms of animal life, the Duke of Argyll says ("The Reign of Law"):—"In all these there is an observed order in the most rigid scientific sense, that is, phenomena in uniform connection and mutual relations which can be made, and are made, the basis of systematic classification. These classifications are imperfect, not because they are founded on ideal connections where none exist, but only because they fail in representing adequately the subtle and pervading order which binds together all living things."

The knowledge of extinct forms of animals and plants has thrown great light upon the regular and progressive development of organisation. The evolution of living beings seems to have commenced with the more rudimentary forms; the more ancient rocks, until very recently, had revealed no traces of life, and what has been lately revealed tends to confirm this view. In the Cambrian rocks of Bray Head, county Wicklow, the *Oldhamia antiqua* is found—it is a form of very simple organisation; and the Rhizopods (*Eozoon canadense*) found in the otherwise Azoic rocks of Canada is among the lowest forms of organised beings. It is only in beds of comparatively recent formation that we meet with animals of the higher classes. When plants first show themselves, even among these the simplest forms have priority. The combinations of life, at first simple, have become more and more complex, until the creation of man, who may be considered the masterpiece of organisation.

If we expose a quantity of pure water to the light and air in the

spring time or summer season we would soon see it producing minute spots of a yellowish or greenish colour. These spots, examined through the microscope, reveal thousands of vegetable forms. Presently thousands of Rhizopods and Infusoria appear, which move and swim about the floating vegetable forms upon which they nourish themselves. Other Infusoria then appear, which, in their turn, pursue and devour the first.

In short, life transforms unorganised into organised matter. Vegetables appear first, then come herbivorous animals, and then come the carnivorous. Life maintains life. The death of one provides food and development to others, for all are bound up together; all assist at the metamorphoses continually occurring in the organic as in the inorganic world, the result being general and profound harmony—harmony always worthy of admiration. The Creator alone is unchangeable, omnipotent, and permanent; all else is transition.

The inhabitants of the water are at least as numerous as those of the solid earth. "Upon a surface less varied than we find on continents," says Humboldt, "the sea contains in its bosom an exuberance of life of which no other portion of the globe could give us any idea. It expands in the north as in the south; in the east as in the west. The seas, above all, abound with this life; in the bosom of the deep, creatures corresponding and harmonising with each other sport and play. Among these the naturalist finds instruction, and the philosopher subjects for meditation. The changes they undergo only impress upon our minds more and more a sentiment of thankfulness to the Author of the universe."

Yes, the ocean in its profoundest depths—its plains and its mountains, its valleys, its precipices—is animated and beautified by the presence of innumerable organised beings. Among these we find the Algæ, solitary or social, erect or drooping, spreading into prairies, grouped in patches, or forming vast forests in the ocean valleys. These submarine forests protect and nourish millions of animals which creep, which run, which swim among them; others again sink into the sands, attach themselves to rocks, or lodge themselves in their crevices; these construct dwellings for themselves; they seek or fly from each other; they pursue or fight, caress each other lovingly, or devour each other without pity. Charles Darwin truly remarks somewhere that our terrestrial forests do not maintain nearly so many living beings as those which swarm in the bosom of the sea. The ocean, which for man is the region of asphyxia and death, is for millions

of animals the region of life and health: there is enjoyment for myriads in its waves; there is happiness on its banks.

The sea influences its numerous inhabitants, animal or vegetable, by its temperature, by its density, by its saltness, by its bitterness, by the never-ceasing agitation of its waves, and by the rapidity of its currents.

We have seen in preceding chapters that the sea only freezes under intense cold, and then only at the surface.

What immense varieties of size, shape, form, and colour, from the nearly invisible algæ which serve to nourish the small zoophytes and molluscs, to the long, slender algæ of fifty, and even 500, yards in length! How vast the disparity between the microscopic Infusoria and the gigantic Whales!

"We find in the sea," says Lacepede, "unity and diversity, which constitute its beauty; grandeur and simplicity, which give it sublimity; puissance and immensity, which command our wonder."

In the following pages we shall figure and describe many inhabitants of the sea; but how many will still remain to be figured and described! From the days of Aristotle research has been succeeded by research, without interruption. "But how vast the field," as Lamarck observes, "which Science has still to cultivate, in order to carry the knowledge already acquired to the degree of perfection of which it is susceptible!"

"When the tide retires from the shore, the sea leaves upon the coast some few of the numberless beings which it carries in its bosom. In the first moments of its retreat, the naturalist may collect a crowd of substances, vegetable and animal, of various characteristic colours and properties. The inhabitants of the coast may find there their food, their commerce, and their occupations. At low water the nearest villages and hamlets send their contingents, old and young, men, women, and children, to the harvest. Some apply themselves to gathering the riband seaweed (*Zostera*), the membranous *Ulva*, the sombre brown *Fucus vesiculosus* a source of great wealth to the dwellers by the sea, being much used in making kelp; others gather the small shells left on the sand; boys mount upon the rocks in search of whelks (*Buccinum*) and of mussels (*Mytilus*), and detach limpets (*Patella*) from the rocks to which they attach themselves. On some coasts shells are sought for their beauty. By turning the stones, or by sounding the crevices of the rocks with a hook at the end of a pole, cuttles and calmars are sometimes surprised—sometimes even

a young conger eel, which has sought refuge there; while the pools, left here and there by the retiring tide are dragged by nets of very small mesh, in which the smaller crustacea, molluscs, and small fish are secured."

In the Mediterranean and other inland seas, where the tide is almost inappreciable, there will be found to exist a great number of animals and Algæ belonging to the deep sea, which the waves or currents very rarely leave upon the sea-shore. There are others, again, so fugitive, or which attach themselves so firmly to the rocks, that we can watch them only in their habitats. It is necessary to study them floating on the surface of the waves, or in their mysterious retirements. Hence it is often necessary that naturalists should study the living productions of the sea, both on the bosom of the ocean as well as on the sea-shore.

The means generally employed for scraping the sea-bottom is a dredge-net, or other suitable engine. In a voyage which Milne-Edwards made round the coast of Sicily, he formed the idea of employing an apparatus invented by Colonel Paulin, which consisted of a metallic casque provided with a visor of glass, and consequently transparent, which was fixed round the neck by means of a copper collar made water-tight by stuffing—a diving-bell, in short, in miniature. It communicated with an air-pump by means of a flexible tube. Four men were employed in serving the pump, two working while the other two rested themselves. Other men held the extremity of a rope, which was passed over a pulley attached at a higher elevation, and enabled them to hoist up the diver with the necessary rapidity in case of emergency. A vigilant observer held in his hand a small signal cord. The immersion of the diver was facilitated by heavy leaden shoes, which assisted him at the same time to maintain his vertical position at the bottom. Milne-Edwards made the descent with his apparatus in three fathoms water with perfect success. He was thus enabled to study, in their most hidden and most inaccessible retreats, the radiate animals, molluscs, crustaceans, and annelids, and by his descriptions he has contributed most essentially to our knowledge of the manners and mode of development of certain inhabitants of the sea, whose sojourn and habits would have seemed to sequestrate them for ever from our observation.

Another and easier mode of studying the living creatures sheltered by the sea was first suggested by M. Charles des Moulins, of Bordeaux, in 1830. The *aquarium*, which is a tank or large water-tight vessel charged with fresh or salt water, according to the

beings it is intended to contain, serves the same purpose for the inhabitants of the deep which the aviary does for the birds of the air—cages of glass being used in place of cages of iron wire or wicker-work, and water taking, in a measure, the place of atmospheric air.

When the globe is filled with fresh water, and molluscs, crustaceans, or fishes are placed in it, it is observed, after a few days, that the water loses its transparency and purity, and becomes slightly corrupt. It necessarily follows that the water must be changed from time to time. Changing the water, however, too frequently causes much suffering, and even death, to the animals. Besides, the new water does not always present the same composition, the same aëration, or the same temperature, with that which is replaced. To obviate this defect, and taking a leaf out of Nature's book, M. des Moulins proposed to put into the vase a certain number of aquatic plants, floating or submerged—duckweed, for example—which would oxygenate the water, and so keep it fit for the animals inhabiting it. It is known that plants assimilate carbon, while decomposing the carbonic acid produced by the respiration of animals, thus disengaging the oxygen indispensable to animal life. In this simple manner was the too constant change of the water obviated. The same happy idea has been successfully applied to salt water; and aquariums for salt water plants and animals have been proposed on a great scale, such as that of the Zoological Gardens of Paris, belonging to the French Acclimatisation Society, in the Bois de Boulogne, inaugurated in 1861. It is a solid stone building of fifty yards in length by about twelve broad, presenting a range of forty tanks made of Angers slate, running north and south. The tanks are nearly cubical, and are lined in front with the strong glass of Saint Gobain. They are lighted from above; but the light is weak, greenish, uniform, and consequently mysterious and gloomy, giving, however, a pretty exact imitation of the submarine light some fathoms down. Each tank contains about 200 gallons of water, and is furnished with rocks disposed a little in the form of an amphitheatre, and arranged in a picturesque manner. Upon the rocks various species of marine algæ are planted. The bottom is of shingle, gravel, and sand, in order to give certain animals a sufficiently natural habitat.

Ten of these tanks are intended for marine animals. The water employed is never changed, but it is kept in continual agitation by a circulation, which is produced by a current of water led from the great pipe which feeds the Bois de Boulogne. This water, being subjected to a strong pressure, compresses a certain portion of air, which, being permitted to act on a portion of the sea water contained

in a closed cylinder placed below the level of the aquarium, makes it ascend, and enter with great force into a reservoir, into which it is thrown from a small jet. The sea water thus pressed absorbs a portion of the air, which is drawn with it into the reservoir. A tube placed in a corner of the reservoir receives the overflow, and conducts it into a closed carbon filter, whence it passes into a gravelly underground reservoir, returning again to the closed cylinder. The water is once more subjected to the pressure of air, and again ascends to the aquarium. The cylinder being underground, a temperature equal to about 16° Centigrade, which is nearly the uniform temperature of the ocean, is easily maintained. During winter the aquarium is heated artifically.

We ought not to conclude our remarks on this subject without a passing allusion to the large aquarium at the Sydenham Palace, and to the still larger one more recently opened at Brighton, which, for abundance of specimens and tastefulness of arrangement, far surpass anything of the sort previously attempted in England.

CHAPTER IV.

PROTOZOA.

"Natura nusquam magis quàm in minimis tota est."
"Nature is nowhere more perfect than in her smaller works."—PLINY.

IT will not be out of place here to offer some remarks on the animal kingdom in general, as well as on the great divisions thereof which form the subject of this volume. But, considering the vastness of the subject, we must be indeed brief. The divisions, classes, orders, families, genera, and species, which naturalists have established in order to study and describe animals, are admirable contrivances for facilitating the study of creatures numerous as the sands of the sea-shore. Without this precious means of logical distribution, the individual mind would recoil before the task of describing the innumerable groups of existing animal life. But the reader must never forget that these methodical divisions are, after all, due to human invention: they form no part of Nature; Linnæus tells us that Nature makes no leaps—*natura non facit saltus*—she passes in a manner almost insensibly from one stage of organisation to another; human systems but try to follow in her footsteps.

When we come to examine the organisms which stand as it were on the confines of the animal and vegetable kingdoms, we realise how difficult it is to see the precise line of demarcation which separates these great kingdoms of Nature. We have seen in "The Vegetable World" germs of the simplest organisation, spores, as in the Algæ, which seem to be invested with some of the characteristics of animal life, for they appear to be gifted with organs of locomotion, namely, vibratile cilia, by means of which they execute movements which are to all appearance quite voluntary. Side by side with these are the fecundating corpuscles, known as *antherozoids* among the Algæ, Mosses, and Ferns, which seem to go and come like the inferior animals, seeking to penetrate into cavities, withdrawing themselves, returning again, and again introducing themselves, and exhibiting all the signs of an apparent effort. If we compare some of the early stages of the Protozoa with these moving

vegetable organisms, we will not find it easy to determine, without considerable study, which is to become the plant and which the animal. It is indeed difficult to trace the precise line of demarcation which it is so desirable to establish between these two kingdoms of Nature.

The word *zoophyte* has been often applied to these lower forms of animal life: it is derived from the Greek word ζῶον, *animal*, and φυτὸν, *plant*. To adopt the name *zoophyte* to indicate a great division of the animal kingdom, would, however, lead the reader to imagine that there is an ambiguity about the creatures designated, or that they belong at once to both kingdoms, or that they might be ranged indifferently in the one or the other. But the so-called zoophytes are animals, and nothing but animals; and the only justification for using a designation which signifies animal-plant is, that many of them have, at first sight, an exterior resemblance to plants.

This likeness between plants and zoophytes was supposed to be nowhere more apparent than in the coral. Rooted upon rocks, the form of its branches many times subdivided, above all, the coloured polyps which at certain stages of their expansion so closely resemble the corolla of a flower, gave the coral, it was thought, all the form and appearance of a plant. Until the eighteenth century most naturalists classed the coral, as Linnæus once did without the least hesitation, in the vegetable world. Réaumur long contended for the contrary opinion. The sea anemone was also cited as another example of the resemblance borne by certain of the lower animals to vegetables. This resemblance, however, is not seen in the group of the lower animals which we prefer to call Protozoa (from πρωτὰ the first, and ζώη life), and we shall not surprise our readers by telling them that the structure of these Protozoa, especially of some of the lower forms is excessively simple. We find among them the first steps in the scale of animal life, and here a very rudimentary organisation was to be expected. In these beings the several parts of the body, in place of being disposed symmetrically on each side of its longitudinal plane, as occurs in animals of a higher organisation, are found to have not as yet become differentiated. The Protozoa we need hardly add have neither an articulate skeleton, either exterior or interior, nor a nervous system. The organs of the senses, other than that perhaps of touch, are altogether absent in the beings which belong to this the lowest class of the lowest division of the animal kingdom.

Several questions arise here: Has the Protozoon sentiment, feeling, preception? Has it consciousness, sense, sensibility? The

question is insoluble; it is sunk in an abyss of obscurity. The coral, or rather the aggregation of living beings which bear the name, are attached to the rock which has seen their birth, and which will witness their death: the Infusoria, of microscopic dimensions, which revolve perpetually in a circle infinitesimally small; the marvellous Amœbæ, which in the space of a minute can change their form a hundred times under the surprised eyes of the observer, are, in truth, mere atoms charged with life. Yet all these beings have an existence to appearance purely vegetative. In their obscure and blind life, have they consciousness or instinct? Do they know what takes place at the three-thousandth part of an inch from their microscopic bodies? To the Creator alone does the knowledge of this mystery belong.

It would be foreign to the object of this work to enumerate all the minute details concerning the innumerable creatures which swarm in the ocean and on its confines. We shall perhaps best consult the convenience of our readers by saying a few words about the Protozoa in general, before proceeding to discuss the three classes which form this division of the animal kingdom.

The Protozoa represent animal life reduced to its most simple expression. They are organised atoms, mere animated and moving points, living sparks. As they are the simplest forms of animal life as regards their structure, so also are they the smallest. Their microscopic dimensions hide them from our view. The discovery of the microscope was a necessary step to our becoming acquainted with many of these beings, whose existence was ignored by the ancient philosophers, and only revealed in the seventeenth century by the discovery of the microscope. When, armed with this marvellous instrument, we examine these minute organisms, as Leuwenhoek did when, for example, he applied his magnifying glass to some infusions of macerated vegetable and animal substances, or when he scrutinised a drop of water taken from the ocean, from a river, or a lake, we, as he did, will discover there a new world, a world which will be partly unveiled in these pages.

Some modern writers believe that the Protozoa are mere cellular organisms, such as we find among the vegetable kingdom. According to this hypothesis, the Protozoa would be to the animal kingdom what the Algæ and Fungi are to the vegetable world. This idea is so far wrong, that it has been founded upon a basis of pure theory. "In reality," says Paul Gervais and Van Beneden, "the animals which we thus designate very rarely resemble elementary plants." The substance of which the bodies of the Protozoa are composed is

habitually destitute of cellular structure. Their bodies are formed of a sort of animated jelly, amorphous and diaphanous, which has received from Dujardin the name of *Sarcode.*

Infinitely varied in their form, the Protozoa are chiefly characterised by the absence of a nervous system, of organs of sense, and in many of them the existence of a distinct alimentary system is still to be ascertained. The more highly organised of the group possess *vibratile cilia*, which act as organs of locomotion as well as enable them to collect their food. Their bodies are sometimes naked, sometimes covered with a siliceous, chalky, or membranous shell, and in some covered with cilia, and in the cortical layer of a species of *Bursaria*, Professor Allman has detected urticating filaments. The Protozoa may be divided into the *Spongida*, the *Rhizopoda*, and the *Infusoria.*

I.—Spongida.

The sponge is a natural production, which has been known from times of the highest antiquity. Aristotle, Pliny, and all other writers who occupied themselves with natural history in ancient times, are agreed in according to it a sensitive life. They recognise the curious fact that the sponge shrinks from the hand which tries to seize it, and clings to the rocks on which it is rooted, as if it would resist the efforts made to detach it. Pliny, Dioscorides, and their commentators, even formed the idea that sponges were capable of feeling, and that they adhered to their native rock by special force. They even distinguished males from females. Erasmus, however, criticising Pliny, concludes that he may pass over all he has written upon the sponge. The sponge, in short, was to the ancients something between a plant and an animal.

Rondelet—the friend of the celebrated Rabelais, whom the merry curate of Meudon designated under the name of *Rondibilis*—who was himself a physician and naturalist of Montpellier, denied at first the existence of sensibility in sponges. He originated the idea that these productions belonged to the vegetable kingdom—an idea which Tournefort, Gaspard Bauhin, Rey, and even Linnæus in the first editions of his "Systema Naturæ," supported by the great authority of their names. Afterwards, influenced by the convincing labours of Trembley and some other observers, Linnæus withdrew the sponges from the vegetable kingdom. He satisfied himself, in short, that certain polyps much resembled sponges in the nature of their parenchyma, and that, on the other hand, the grouping of sponges with plants was not such

a one as could be maintained. Neuremberg, Peyssonnel, and Trembley maintained the animal nature of sponges, and their views were adopted by Linnæus, Guettard, Donati, Lamouroux, and Ehrenberg on the Continent, and by Ellis, Fleming, and Grant in England. Sponges live at the bottom of the seas in from 500 to 1,250 fathoms of water, among the clefts and crevices of the rocks, always adhering and attaching themselves, not only to inorganic bodies, but even growing on algæ and animals, spreading, erect, or pendent, according to the body which supports them, and their natural habit.

The power of fixing themselves to other objects, which certain animals possess, is very singular; nevertheless, it is certain that whole tribes exist, the species of which are strictly adherent, which live and die attached to some rock or other object, and among these are the sponges. It follows then that but for their cilia they would be wholly dependent on external agencies for their means of existence. "The poor little creatures," says Alfred Frédol, "receive their nourishment from the wave which washes past them; they inhale and respire the bitter water all their lives; they are insensible to that which is only the hundredth part of an inch from their mouth."

In the months of April and May these sponges develop ova which are round, yellow, or white, and from whence proceed certain ovoid granular embryos, furnished towards their largest extremity with small vibratile cilia. They are either carried off by the currents, or form swarms of larvæ round the parent sponge. They swim about with a gliding wavy motion, and when they have been some time in the water they usually come to the surface. During two or three days they seem to seek a convenient place to fix themselves. Once fixed, the larval form loses its cilia, spreads itself out, and soon grows into the form of its parent.

"They soon attach themselves to some foreign body," says M. Milne-Edwards, "and become henceforth immovable; no longer giving signs either of sensibility or of contractibilty, while in their enlargement they are completely transformed. The substance of their bodies is channelled and riddled with holes—the fibrous framework is completed—the sponge is formed."

Their interior organisation consists of contractile cellules and numerous spicula—"a tribe," says Gosse, "of the most debatable forms of life, long denied a right to stand in the animal ranks at all, and even still admitted there doubtingly and grudgingly by some excellent naturalists. Yet such they certainly are, established beyond reasonable controversy as true and proper examples of animal life."

It may, indeed, be safely asserted that all naturalists are now

satisfied of the animal nature of sponges, although they once were thought to represent the lowest and most obscure grade of animal existence, and that so close to the confines of the vegetable world, that it was considered difficult in some species to determine whether they were on the one side or the other. "Several of them, however," says Mr. Gosse, "if viewed with a lens under water while in a living state, display vigorous currents constantly pouring forth from certain orifices; and we necessarily infer that the water thus ejected must be constantly taken in through some other channel. On tearing the mass open, we see that the whole substance is perforated in all directions by irregular canals, leading into each other, of which some are slender, and communicate with the surface by minute but numerous pores, and others are wide, and open by ample orifices; through the former the water is admitted, through the latter it is ejected."

The physiological function of the tubes and orifices which present themselves on all parts of the sponge has been interpreted in various ways. Ellis, writing in 1765, supposes that they were the orifices of the cells occupied by the polypes. In 1816 Lamarck still advocated this opinion; and even now we find the observer whose notes M. Frédol has edited with so much judgment asserting that "the inhabitants of the sponge are a species of fleeting, transparent, gelatinous tubes, susceptible of extension and contraction; young polypes, as we may call them, without consistence, without cilia; incipient polypes, in short, of very simple but sufficient organisation. The animalcule of the sponge is a stomach, without arms, very simple, very elementary—in short, an animal all stomach!"

This mode of considering the sponge is not conformable to the views of the leaders of modern science. Professor Milne-Edwards, for instance, in place of seeing in the sponge a collection of united beings, forming as it were a colony, considers each to be an isolated being, a unique individual. The innumerable canals by which the sponge is traversed, according to that author, are at once its digestive organs and breathing pores. The vibratile cilia are necessary to the renewed aëration of the water required as a respiratory fluid in the interior canals of the sponge. The currents in these channels have one constant direction. The water penetrates the sponge by numerous orifices of minute dimensions and irregular disposition; it traverses channels in the body of the mass, and finally makes its escape by special openings. According to this view, the channels of the sponge perform the two functions of digestion and respiration. The rapid currents of aërated water which traverse them lead into

them the substances necessary to the nourishment of these strange creatures, and at the same time carry off all excremental matter. At the same time, the walls of these canals present a large absorbing surface, which separates the oxygen with which the water is charged, and disengages the carbonic acid which results from respiration.

Again, Dr. Johnson omitted them altogether from his work on "British Zoophytes." "If they are not the production of polypi," he says, "the zoologist who retains them in his province must contend that they are individually animals, an opinion to which I cannot assent, seeing that they have no animal structure or individual organs, and exhibit not one function usually supposed to be characteristic of the animal kingdom." Gervais and Van Beneden consider, as Milne-Edwards does, that the embryos are at first movable, then fixed, many of them uniting together, and melting, as it were, into one common colony, which becomes a sponge, such as we see it. An isolated embryo might also, by throwing out germs, produce a similar colony, which would thus become a product of agamous generation. Thus it appears that Science is far from being settled in its views as to the organisation and development of these obscure and complex creatures; nor is it more advanced in its knowledge of the duration of life and the quickness of growth in sponges.

It is not to be denied, also, that these beings constitute, in spite of the investigations of modern naturalists, a group still somewhat problematical as to their position in the scale of animal life, and that they are still very imperfectly known as regards their internal organisation.

Some sponges form masses of a light elastic tissue, which is, at the same time resistant. The number of species or supposed species at present known is very large. Dr. Bowerbank, in his work on "British Sponges," published in 1866, describes nearly 200; and many species have been since added to our Fauna. They are met with presenting every possible diversity of size and outward configuration. Many of them are very small, others are of immense size. Neptune's Cup (*Raphiophora patera*, Gray) is met with off Singapore, and forms an immense mass, upwards of three or four feet in height. The skeleton of sponges is usually composed of horny, anastomising fibres (Fig. 9). In some sponges, as *Grantia*, this is altogether wanting. In others again, as in *Pheronema*, the skeleton is chiefly composed of siliceous fibres. Calcareous or siliceous bodies, called spicula, are met with in most sponges, and vary very much in form and size. Many of these form most beautiful and attractive objects for microscopic examination. Every one is familiar

Fig. 9.—Sponge, half the natural size, attached to its rocky bed.

with the porous aspect of any ordinary sponge. It will be found on examination that these pores are of two kinds, the larger ones called

"oscula," and the smaller distinguished as "pores." In the living state of the sponge water is being constantly absorbed by the latter, while currents of water will be seen issuing out from the former, thus serving to convey minute particles of food, as well as contributing to the general aëration of the entire mass. It is also worthy of note that sponges possess in a marked degree reparative powers.

At the present time sponge-fishing takes place principally in the Grecian Archipelago and the Syrian littoral. The Greeks and Syrians sell the product of their fishing to the Western nations, and the trade has been immensely extended in recent times, the sponge having become an almost necessary adjunct of the toilet as well as the stable.

Fishing usually commences towards the beginning of June on the coast of Syria, and finishes at the end of October. But the months of July and August are peculiarly favourable to the sponge harvest, if we may use the term. Latakia furnishes about ten boats to the fishery, Batroun twenty, Tripoli twenty-five to thirty, Kalki fifty, Simi about 170 to 180, and Kalminos more than 200.

The operations of one of these boats fishing for sponges on the Syrian coast is represented in PLATE I. The boat's crew consists of four or five men, who scatter themselves along the coast for two or three miles in search of sponges under the cliffs and ledges of rock. Sponges of inferior quality are gathered in shallow waters. The finer kinds are found only at a depth of from twenty to thirty fathoms. The first are fished for with three-toothed harpoons, by the aid of which they are torn from their native rock; but not without deteriorating them more or less. The finer kinds of sponges, on the other hand, are collected by divers; aided by a knife, they are carefully detached. Thus, the price of a sponge brought up by diving is much more considerable than that of a harpooned sponge. Among divers, those of Kalminos and of Psara are particularly renowned. They will descend to the depth of twenty-five fathoms, remain down a shorter time than the Syrian divers, and yet bring up a more abundant harvest. The fishing of the Archipelago furnishes few fine sponges to commerce, but a great quantity of very common ones. The Syrian fisheries furnish many of the finer kinds, which find a ready market in France; they are of medium size. On the other hand, those which are furnished from the Barbary coast are of great dimensions, of a very fine tissue, and much sought for in England.

Sponge-fishing is carried on at various other stations in the Mediterranean, but without any intelligent direction, and in consequence it is effected without any conservative foresight. At the

I.—Sponge Fishing on the Coast of Syria.

same time, however, the trade in this product goes on yearly increasing. But it is only a question of time when the trade shall cease; the demand which every year clears the submarine fields of these sponges causing such destruction that their reproduction will soon cease to be adequate.

In order to prevent such a result, it is very desirable that attempts should at once be made to naturalise the several species of sponges on the French and Algerian coasts, and that their cultivation and reproduction should be protected. For this purpose the rocky coasts of the Mediterranean, from Cape Cruz to Nice, at Hyères, and even some of the salt lakes of the departments in Algeria near the Mediterranean, might be utilised; large portions of the Southern Italian littoral zone would also be available for this purpose.

M. Lamiral considered that the composition of the water of the Mediterranean being nearly the same on the coasts of France, of Algeria, and of Syria, the difference of temperature between these two places—especially at the depth where the sponges flourish most—would not interfere with their existence, and he believed that their acclimatisation on the coasts of France and Algeria would be a certain success. He remarked, moreover, that the more the sponges advanced towards the north the finer and compacter their tissues became; and he argued from this fact that a considerable improvement in their quality would result from the experiment.

The only difficulty, then, would be in the transplanting sponges from the Syrian waters to the coasts of France and Algeria. A submarine boat, such as M. Lamiral makes use of for scientific operations conducted in deep water, would, according to this naturalist, give every facility for collecting sponges for the purpose. This boat can descend to great depths, and its crew can even dwell there for a considerable time, for it is continually fed with fresh air, which is conveyed by an air-pump and tube into the interior of the boat from above, so that the men could readily select such specimens as were suited for acclimatising; removing whole blocks of rock along with them, either by placing them in cases pierced with holes, or by towing them to their new abode.

It might be possible, too, to collect the very young forms of sponge in the months of April and May, shortly after they have commenced their independent existence, and to transplant them to favourable localities. At the end of three years, when these true submarine fields would be probably ripe for harvesting, they could be farmed out for methodical collection, which would be effected by means of diving boats.

The finer varieties of toilet sponge produce a high price, often as much as forty shillings the pound weight for very choice specimens, a price which few commercial products obtain, and which prohibits their use, in short, to all but the wealthy. It is, therefore, very desirable that attempts should be made to carry out the submarine enterprise of M. Lamiral. With the assistance of the Acclimatisation Society of Paris, some experiments have already been made in this direction—so far without any satisfactory results, it is true, but everything indicates that by perseverance we shall see the enterprise crownod by the success it merits.

In the Red Sea the Arabs fish for sponges by diving, the produce being either sold to the English at Aden or sent to Egypt.

On the Bahama banks, and in the Gulf of Mexico, the sponges grow in water of small depth, The fishermen—Spanish, American, and English—sink a long mast or perch into the water moored near the boat, down which they drop upon the sponges; by this means they are easily gathered.

The fine soft Syrian sponge is distinguished by its lightness, its fine flaxen colour, its form, which is that of a cup, its surface convex, voluted, pierced with innumerable small orifices, the concave part of which presents canals of much greater diameter, which are prolonged to the exterior surface in such a manner that the summit is nearly always pierced throughout in many places. This sponge is sometimes blanched by the aid of caustic alkalies; but this preparation not only helps to destroy its texture, but also changes its colour. This sponge is specially employed for the toilet, and its price is high. Specimens which are round-shaped, large, and soft, sometimes produce very high prices.

The fine sponge of the Grecian Archipelago is scarcely distinguishable from that of Syria, either before or after being cleansed; nevertheless, it is weightier, its texture is not so fine, and the holes with which it is pierced are at once larger and less in number. It is nearly of the same country as the former, in fact, the fishing for it extends along the Syrian coast as well as the littoral zone of the Archipelago and Barbary.

The fine hard sponge, called Greek, is less sought for than either of the preceding; it is, however, most useful for domestic and for certain industrial purposes. Its mass is irregular, it is of a yellowish colour; it is hard and compact, and pierced with small holes.

The white sponge of Syria, called Venetian, is esteemed for its lightness, the regularity of its form, and its solidity. In its rough state it is brown in colour, of a fine texture, compact and firm.

When cleansed it becomes flaxen-coloured and of a looser texture. The orifice of the great channels which traverse it are rough and bristly.

The brown Barbary sponge, when first taken out of the water, presents itself as an elongated flattened body, gelatinous, and charged with blackish mud. It is then hard, heavy, coarse, and of a reddish colour. When well washed in water, it becomes round in shape, still remaining heavy and reddish. It presents many gaps, the intervals of which are occupied by a sinuous and tenacious network. It is valuable for domestic use, because of the facility with which it absorbs water, and its great strength.

Other sorts of sponges are very abundant. The Blonde Sponge of the Archipelago, often confounded with the Venetian; the Hard Barbary Sponge, called Gelina, which only comes by accident into France; the Salonica Sponge is of middling quality; finally, the Bahama Sponge, from the Antilles, is wanting in flexibility, and is a little harsh, and so is sold at a low price, having few useful properties to recommend it.

Many species of Sponge are described as inhabiting the British seas, but none are of any commercial value.

No very satisfactory classification of the Sponges has as yet been made, although many recent writers have attempted with more or less success to arrange the very numerous forms now known into definite groups. Among these we may mention Dr. J. E. Gray, Dr. Bowerbank, and Professor Oscar Schmidt. With a few exceptions, all sponges, as we have seen, contain spicules; these are either siliceous or calcareous. We may therefore divide the sponges into two sections, the first being called

Calcarea.

Skeleton chiefly composed of calcareous spicules, which are generally three-rayed. All the species are marine, and none appear to attain large dimensions, while some of the very smallest sponges known belong to this section. *Grantia compressa*, one of our commonest British sponges, will serve as an example.

Silicea.

Skeleton mostly horny, most frequently strengthened with siliceous spicules; these sometimes absent; and, in at least one genus, the sarcode becomes not even differentiated into a horny skeleton. The sponges belonging to this section are found both in fresh and

salt water. Professor O. Schmidt proposes to divide it into three divisions :—

1. Where the spicules assume a sex-radiate type. To this will belong some of the most remarkable and beautiful of sponges, as *Euplectella*, *Aphrocallistes*, *Pheronema*.

2. Where the spicules are anchor-shaped, or of a pyramidal form, containing many very familiar genera, especially the genus *Spongilla*, met with in fresh water.

3. Where the spicules are monaxial, polyaxial, or wanting. Here, amid a host of genera and species, would be placed the genus *Spongia*, to one or more species of which the various sponges previously alluded to as Sponges of Commerce, must be referred. (For *Spongia officinalis*, see Fig. 9).

Rhizopoda.

Gervais and Van Beneden include under the name of *Rhizopods*, or *root-footed* animals (so called from ῥίζα *root;* πούς, ποδός, *footed animals*), those of the simplest organisation, which may be characterised by the absence of a distinct digestive cavity, and by the presence of diverging processes, or pseudopodia, which admit of extension, and are sometimes simple, sometimes branched. These pseudopodia can be completely withdrawn into the body substance of the Rhizopod, and they receive their technical name from the fact that they in many cases assist in the locomotion of these animals.

The Rhizopods are found both in fresh and salt water, but the marine forms are much the more numerous. The class is divided into three orders, namely, the *Lobosa*, the *Reticulosa*, and the *Radiolaria*.

Lobosa, or Amœbina:

In nearly all decaying animal and vegetable infusions, not quite putrid, upon all oozy beds which have remained for some time covered by fresh or sea water, as well as in our lakes and peat pools, we find the singular beings which belong to this Order. They are among the simplest organisms in creation, being reduced to but a mere particle of living matter. Their bodies are formed of a gelatinous substance, without any appreciable organisation. The quantity of matter which forms them is so small, that it becomes incredibly diaphanous, and so transparent, that the eye, assisted by the powers of the microscope, can often only take cognisance of it by a careful arrangement of the light.

It would be difficult to say exactly what is the form these creatures ssume. They frequently have the appearance of small, rounded nasses, like drops of water; but, whatever their form may be, it is ften so unstable, that it changes, so to speak, every moment. 'his instability is one characteristic manifestation of life in the *lmœbæ*, which are naked beings, without any apparent organisation; n fact, they may be said to occupy the first step in the scale of reation.

If we examine one, at first it looks like a transparent immovable rop. We then see it putting forth a pseudopod, which, gliding like streak of oil under the thin covering glass, as we view it through a icroscope, begins by fixing itself to some point, afterwards slowly ttracting to itself the whole of its body mass, and thus gradually ncreasing its bulk under the observer's eye.

The *Amœbæ*, according to their dimensions and degree of develop-ent and activity, successively emit a greater or smaller number of seudopods, none of which are precisely alike, but after having ppeared for a short time, each successively will be seen to re-enter e common mass, with which it becomes completely incorporated. ariable in their respective forms, these pseudopods present ap-earances quite different in the several genera. They are more or ss attenuated, and often branching; sometimes they spring in all irections from the animal mass.

If we ask how these animals are nourished in which no digestive pparatus can be distinguished, the question is difficult to answer. : was once thought that they are nourished by simple absorption, nd by absorption only. In the interior of the gelatinous mass which onstitutes these animals, however, microscopic algæ are frequently iscovered. Indeed, some of them are very voracious feeders, and ay be seen completely stuffed with diatoms, or pretty green desmids. We can conceive," says Dujardin, "how these objects have pene-ated to the interior, if we remark that in creeping on the surface of e glass, to which they adhere very exactly, the *Amœbæ*, can be ade to receive by pressure foreign substances into their own bodies / means of the alternate contraction and extension of the various arts natural to them.

The *Amœbæ* are often observed to be tinted red or green; this pparently arises from a special colouring matter which has been sorbed into their body substance, and the brightness of their colour in direct proportion to their state of health.

The question arises, How do these creatures, so simple in their ganisation, propagate their species?

It is believed that they are chiefly multiplied by parting with a portion of their body substance, which is enabled to take on an independent existence, and thus form a new individual. This is what naturalists term generation by division—*i.e.*, *fission*. The absence of a nutritive and reproductive system in the *Amœbæ*, and the want of stability in their forms, explain how nearly impossible it is to characterise as species the numerous individuals to be met with living in fresh or salt water.

We shall be able to form some idea of the appearance of these

Fig. 10.—Amœba princeps (Ehrenberg), magnified 100 times.

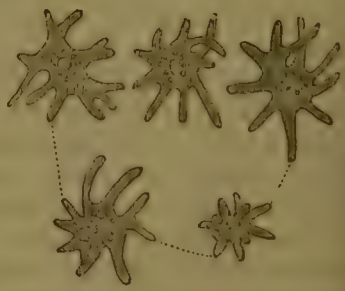


Fig. 11.—Various forms of Amœba diffluens (Muller), magnified.

beings, rendered mysterious by their very simplicity, by throwing a glance upon the two accompanying figures (Figs. 10 and 11), borrowed from the Atlas of Dujardin's "Les Infusoires," which we shall have occasion to quote more than once.

We have said that the *Amœbæ* change their form every few moments under the very eyes of the observer. Fig. 10 represents some of the changes of form through which they pass when examined under the microscope.

Dujardin points out very clearly the identity of structure between organisms like *Amœba* and such forms as *Difflugia* and *Arcella*. All these creatures are without a trace of mouth or true digestive

cavity, but although they have neither mouth nor stomach, yet, according to Professor Kölliker, and as has been mentioned before, they take in solid nutriment, and reject what is indigestible. When in its progress through the water one of these minute organisms approaches one of the equally minute Algæ, from which it draws nourishment, it seizes the plant with its pseudopods, and gradually encloses it on all sides; the pseudopods, to all appearance, becoming more or less shortened in the process. In this way the captive is brought close to the surface of the body; a cavity is apparently then formed, in which the prey is lodged, which closes round it on all sides. In this situation it is gradually drawn towards the centre, and passes at last entirely into the mass, when the engulfed morsel is gradually dissolved and digested.

Reticulosa, or Foraminifera.

What, then, is a Foraminifer? It is a very small calcareous shell nearly invisible to the naked eye; for, in general, its dimensions range between ·005 to ·050 of an inch in length. Examine under a microscope the sand of the ocean, and it will be found that one-half of it consists of the débris of minute shells, of various but well-defined forms, each pierced with a number of holes. To this they are indebted for their name Foraminifera, from *foramen*, a hole. With these microscopic animals Nature has worked wonders in geological times; nor have the wonders ceased in our days.

The sand of the littoral zone of all existing seas is so full of these minute but elegant shells, that it is often nearly one half composed of them. Ehrenberg, the celebrated German microscopist, was recently invited by the Prussian Government to assist in tracing the robbery of a special case of wine. It had been re-packed in littoral sand only found in an ancient sea-board in Germany. The criminal was thus detected. M. d'Orbigny found in three grammes (forty-six grains troy) of sand from the Antilles, 440,000 shells of Foraminifera. Bianchi found in thirty grammes (467 grains) from the Adriatic, 6,000 of these shells. If we calculate from these facts the proportion of these beings contained in a cubic metre alone of sea-sand, we reach a figure which passes all conception. What would this be if we could extend the calculation to the immensity of surface covered by the waves which surround the globe?

M. d'Orbigny has satisfied himself, by microscopic examination of sands from all parts of the globe, that it is the débris of Foraminifera along with the sea-sand, which form, in all existing seas, those

enormous deposits which raise banks, obstruct the navigation in gulfs and straits, and fill up ports, as may be seen in the port of Alexandria. In common with the corals and madrepores, the Foraminifera are great agents in helping to form the isles which surge up under our eyes from the bosom of the ocean in the warmer regions of the globe. Thus may these little bodies, scarcely appreciable to the sight, suffice by their accumulations to fill up seas, while performing, too, a very considerable part in the great operations of Nature.

Many beds of the terrestrial crust consist entirely of the remains of Foraminifera. In the most remote ages in the history of our planet, they must have lived in innumerable swarms in the seas of the period; they buried themselves in the bottoms of the seas, and their shells, heaped up during many ages, now form hills of great thickness and extent. We may say, to give an example, that during the Carboniferous period, a single species of *Fusulina* has formed in Russia and the United States enormous beds of calcareous rock. Many beds of cretaceous formation are, in great part, composed of Foraminifera, and they exist in immense numbers in the white chalk which covers and forms the vast mountains ranging from Champagne in France nearly to the centre of England.

But it is to the Tertiary formation that this group has contributed the most enormous deposits. The Nummulitic formation extends from the Alps to the Carpathians; is met with in Algiers and Morocco. In Egypt it was largely quarried for the building of the Pyramids. It is next met with in Asia Minor, and has been traced across Persia, and as far eastward as Bengal and the frontiers of China. The remains of these creatures are so abundant in the Paris chalk, that M. d'Orbigny found upwards of 58,000 in a small block (scarcely exceeding a cubic inch) of chalk from the quarries of Chantilly. This fact, according to this author, implies the existence of 3,000,000,000 of them in the cubic mètre (thirty-nine inches square and a small fraction) of rock! As the chalk from these quarries has served to build Paris, as well as the towns and villages of the neighbouring departments, it may be said that Paris, and other great centres of population which surround it, are built with the shells of these microscopic animals.

Fig. 12 represents a drawing from Nature, by Messrs. d'Archiac and Haime, of a piece of nummulitic rock, from Nousse, in the Landes, which contains several species of Foraminifers. In the celebrated quarries of St. Peter, at Maestrecht, the *Calcarina calcitrapoides* of Lamarck is found in the upper chalk (Fig. 13). In the calcareous formation of Chaussy, in the Seine and Oise district, and other parts

of the Paris basin, the *Fabularia discolithes* (Fig. 14) of Defrance, and the *Alveolina ovoïdea* of d'Orbigny (Fig. 15) are found, and the

Fig. 12.—Nummulites Rouaulti (d'Archiac and J. Haime).

Fig. 13.—Calcarina (Siderolites) calcitrapoides (Lamarck), natural size and magnified.

Dactylopora cylindracea of Lamarck (Fig. 16) is found in the eocene formation of Valmondois, and in the chalk of Grignon. At first,

this little creature was thought to be a polyzoon; but d'Orbigny, in his "Prodrome de Paléontologie," has correctly placed it among the Foraminifera, thinking that it appeared to occupy a place between the two classes.

Fig. 14.—Fabularia discolithes (Defrance), natural size and magnified.

Our exact knowledge of the Foraminifera is of comparatively recent date. Great numbers of minute particles, of regular and symmetrical form, were long distinguished as existing on the sands of the sea-shore. These early attracted the attention of observers. But with the discovery of the microscope, these small elegant shells, which were among the curiosities revealed by the instrument, assumed immense importance. Linnæus placed them with the beautiful genus *Nautilus* as a group, which would include, according to that author, all the multilocular shells. In 1804 Lamarck also classed them among

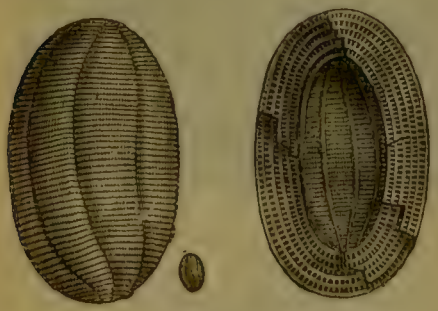


Fig. 15.—Alveolina ovoïdea (d'Orbigny), natural size and magnified.

Fig. 16.—Dactylopora cylindracea (Lamarck), natural size and magnified.

the molluscous cephalopods. But Alcide d'Orbigny, who had devoted long years to their study and observation, and may be considered the great historian of the Foraminifera, showed that this method of classification was inexact. Dujardin separated them altogether from the class of molluscs, and showed that they ought to be consigned to a much lower class of animals.

We have stated that the Foraminifera are of microscopic dimensions. With some trifling exceptions, this is generally true; but

there exist a number of recent species which are visible to the naked eye. Some species of Orbitolites are nearly half an inch in diameter, and the discs of Cycloclypeus, dredged living off the coast of Borneo, are more than two inches in diameter; and among fossil forms of large dimensions may be mentioned *Parkeria* (Carpenter), from the Upper Greensand near Cambridge, which sometimes reaches to three inches in length; and *Loftusia* (Brady), from Persia, specimens of which have been met with three inches long and one inch and a half in diameter. Here also allusion may be made to the gigantic *Eozoon canadense*, lately discovered in the Palæozoic rocks of Canada.

After these remarks, we may venture to give some idea of the structure and classification of beings whose part in the work of creation has in former times been so considerable.

The existing Foraminifera are by no means equally distributed in every ocean. Some genera belong to warm countries, others to temperate and cold climates. They are much more numerous, however, and much more varied in their forms, in warm than in cold climates.

And first as to their structure. We find this to consist of a soft sarcodous material of the same nature as that met with among the Lobosa, and in addition they possess a calcareous skeleton. There is even less approach than with the Amœbæ to either shape, size, or number in their pseudopodial extensions—these often present themselves as marvellously attenuated threads, requiring very high powers indeed of the microscope to discern them. They coalesce both readily and completely with one another, while along their margins streams of granules may be seen continuously passing. There is an apparent absence either of "nucleus" or of a "contractile vesicle," which were occasionally present among the Lobosa. By far the larger number are enclosed in calcareous shells, which are perforated with minute pore-like openings for the escape of the pseudopods, and from the presence of which the familiar name of Foraminifera has been given to the class. These pseudopodial extensions present in this group a peculiar reticulated character, whence the name of Reticulosa, given to it by Dr. Carpenter, whose monograph on the group is a monument of patient industry and research.

We have already said that the shells of these minute creatures vary much in form. They are generally many-chambered, each chamber communicating by pores in its walls. Alcide d'Orbigny, to whom—until Carpenter's "Introduction to the Study of the Foraminifera" was published—we owed almost all that was known of the class, has distributed it into six families, making the form of the shell

the basis of his arrangement. These six families include sixty genera, and more than 1,600 species, the families being as follows:—

I. *Monostega.*—Body consisting of a single segment. Shell of a single chamber.

II. *Stichostega.*—Body composed of segments, arranged in a single

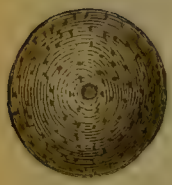


Fig. 17.—Orbulina universa.

Fig. 18.—Dentalina subarcuata.

Fig. 19.—Operculina.

Fig. 20.—Nummulina perforata.

Fig. 21.—Cassidulina lævigata.

Fig. 22.—Textularia variabilis.

Fig. 23.—Spiroloculina depressa.

single line. Shell in chambers, superimposed linearly on a straight or curved axis.

III. *Helicostega.*—Body composed of segments, spirally arranged. Chambers piled or superimposed on one axis, forming a spiral.

IV. *Entomiostega.*—Body composed of alternating segment forming a spiral. Chambers superimposed on two alternating axes, also forming a spiral.

V. *Enallostega.*—Body composed of alternate segments not

forming a spiral. Chambers disposed alternately along two or three axes, also non-spiral.

VI. *Agathistega.*—Body composed of segments wound round an axis. Chambers formed round a common axis, each investing half the circumference.

One of the simplest forms of Foraminifer is illustrated by Fig. 17 (*Orbulina universa*), which is a small spherical shell, having a lateral aperture, the interior of which has been occupied by the living sarcode, to which the shell owes its existence. In *Dentalina subarcuata* the shell (Fig. 18), advances beyond this simple type by a process of linear budding, the first cell being spherical, with an opening through which a second segment is formed, generally a little larger than the first. This new growth is successively followed by others developed in the same way, until the organism attains its maturity, when it exhibits a series of cells arranged end on end, in a slightly curved line.

In the next group the gemmation takes a spiral form, producing the nautilus shape which misled the earlier naturalists. In some cases all the convolutions are visible, as in *Operculina* (Fig. 19). In others, the external convolutions conceal those previously formed, as in *Nummulina perforata* (Fig. 20), *Textularia variabilis* (Fig. 22), and *Alveolina ovoïdea*, d'Orbigny (Fig. 16), the latter of its natural size.

In the fourth group the shell is spiral, with the chamber equilateral, with a larger and smaller side; the position being alternately reversed, as the segments are multiplied, as in *Cassidulina lævigata* (Fig. 21). In the succeeding group the new segments are arranged alternately on opposite sides of the central line, as in *Textularia variabilis* (Fig. 22), thus forming two alternating non-spiral parallel segments, each connected by a single orifice.

The sixth family differs entirely in appearance and structure from the other Foraminifera. The shells are more opaque than those met with in the other orders, having a resemblance to white porcelain, and present a rich amber-brown hue when viewed by transmitted light. They are more or less oblong, each new segment being nearly equal to the entire length of the shell, so that the terminal orifice presents itself alternately at its opposite extremities, sometimes in one uniform plane, as in *Spiroloculina depressa* (Fig. 23), and *Rotalia* (Fig. 24). At other times each new segment, instead of being exactly opposite each other, is a little on one side.

This classification of d'Orbigny must now yield to that proposed by Dr. Carpenter in his work before referred to. He divides the order

Reticularia into two sub-orders; 1. Imperforata; and 2. Perforata. The former contains three provisional families:—1. Test membranous—Gromida; 2. Shell porcellanous—Miliolida; 3. Shell arenaceous—Lituolida (Figs. 14, 15, 16, 23). The latter containing the families, not as yet precisely defined, of:—Lagenida (Fig. 18); Globigerinida (Figs. 17, 21, 22); Nummulinida (Figs. 19, 20, 24).

Professor Williamson has shown that the shell enclosing each new segment is at first very thin; but as additional calcareous chambers are formed, each addition not only encases the new gemmation of the

Fig. 24.—Rotalia.

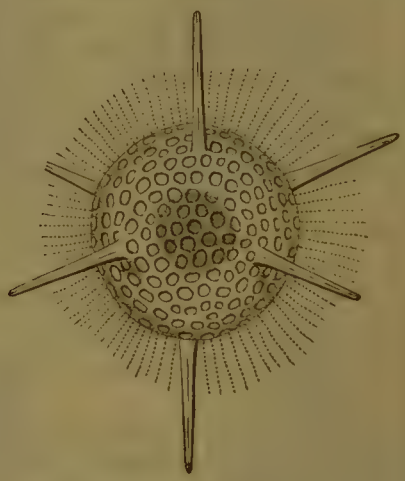


Fig. 25.—Haliomma hexacanthum.

soft animal, but extends over all the exterior of the previously formed shell. The exact manner in which this is accomplished is doubtful; but it is probable that the soft animal has the power of diffusing its substance over the shell, and then depositing upon its surface additional layers of calcareous matter.

Radiolaria.

The order *Radiolaria* contains Rhizopods, in which the pseudopods are very numerous, and long and slender. They issue from the body mass in a radial direction, and do not undergo that complete fusion which occurs in the Foraminifera. In some of the Actinophryna there is a more or less firm envelope; in Acanthometrina the body is supported by a regular framework of siliceous spicules;

Haliomma hexacanthum, figured from Müller (Fig. 25), is an example of the Polycystina, in which the body is more or less encased in a siliceous shell; while in the Thallasicollina the body is composed of aggregations of more or less fully differentiated cells, supported upon a framework of siliceous spicules, and thus obviously establishes a transition between typical Rhizopods and the Sponges.

Before passing on to the Infusoria, a few words may be offered on the *Noctiluca*, an organism certainly belonging to the Protozoa. One species only of this genus has been described, which occurs occasionally on the English coast in prodigious numbers, and is the chief cause of the diffused phosphorescence of our seas. It is a small creature, scarcely the hundredth part of an inch in diameter (Fig. 26, *Noctiluca miliaris*). It was discovered by M. Surriray, in 1810, who describes it as a spherical gelatinous mass, scarcely bigger than a pin's head, with a long filiform tentacular appendage, a mouth, an œsophagus, one or many stomachs, and branching ovaries—thus exhibiting a certain complexity of organisation, pointing to affinities with the true Infusoria. De Blainville placed it among the *Diphydæ*. Van Beneden and Doyère, on the other hand, deny its relation to the Acalephæ, conceiving its organisation to be much more simple, and place it with the Rhizopoda. Quatrefages adopts the same view, denying the existence of a true mouth or intestinal canal: he considers the so-called stomachs as simple "vacuoles," similar to those observed in the Rhizopoda and Infusoria. Prof. Huxley, in the *Journal of Microscopical Science* (vol. iii.), says it may be described as a gelatinous transparent body, about one-sixtieth of an inch in diameter and having very nearly the form of a peach, a filiform tentacle, equal in length to the diameter of the body, occupying the place where the stalk of the peach might be, which depends from it, and exhibits slow wavy motions when the creature is in full activity. "I have even seen a Noctiluca," he adds, "appear to push against obstacles with this tentacle."

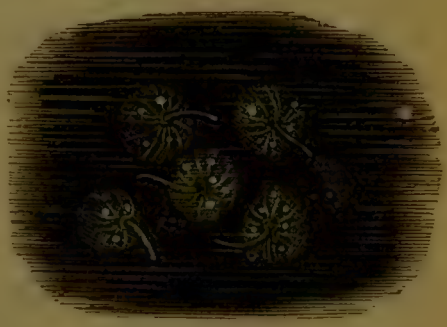


Fig 26.—Noctiluca miliaris (magnified).

"The body," he continues, "is composed of a structureless and somewhat dense external membrane, which is continued on to the

tentacle. Beneath this is a layer of granules, or rather a gelatinous membrane, through the substance of which minute granules are scattered without any very definite arrangement; from hence arises a network of very delicate fibrils, whose meshes are not more than the three-hundredth part of an inch in diameter, which gradually pass internally—the reticulation becoming more and more open—into coarser fibres, taking a convergent direction towards the stomach and nucleus. All these fibres and fibrils are covered with minute granules, which are usually larger towards the centre."

Prof. Huxley is inclined to think, from all he has observed, that the animal has a definite alimentary cavity, and that this cavity has an excretory aperture distinct from the mouth. These facts, together with the existence of a dental armature, greatly increase its affinity to such forms as Colpoda and Nassula among the Infusoria, while the general absence of cilia over the body, and the wide differences in detail, would require the constitution of at least a distinct family for this singular creature.

Surriray discovered the *Noctiluca* while investigating the cause of the phosphorescence of sea water at Havre, where it was abundant in the basins, sometimes in such abundance as to form a scum on the surface of the water of considerable thickness. "This singular little creature," says M. Frédol, "offers here and there in its interior certain granules, probably germs, and also luminous points, which appear and disappear with great rapidity, the least agitation bringing out their lustre." The *Noctiluca* are so abundant in the Mediterranean and on many parts of our English coasts, that in a cubic foot of sea water, which has been rendered phosphorescent by their presence, it is calculated that there may exist about 25,000. We now come to the

Infusoria.

Of this very interesting group a large proportion are marine, and very many numerous varieties of them are found in the British seas. In their minuteness and variety they almost baffle the attempts of naturalists to classify them.

We find both fresh and salt water inhabited by legions of these active, ever-moving beings, of dimensions so small as to be inappreciable to the naked eye; these minute creatures are disseminated by millions and thousands of millions in the great deep, and all knowledge of them would have escaped us, as they escaped the knowledge of former scientific men, but for the discovery of the microscope, the sixth sense of man, as it has been happily called by the poet and

historian Michelet. And M. Frédol tells us that "the infusorial animalcules are so small that a drop of water may contain them in many millions. They exist in all waters, the fresh as well as the salt, the cold as well as the hot. The great rivers are continually discharging them in vast quantities into the sea."

The Ganges transports them in the course of one year in masses equal to six or eight times the size of the great pyramid of Egypt.

Water collected between the Philippine and the Marianne Isles, at the depth of 22,000 feet (making some allowance for erroneous soundings), has been found to contain 116 species. Near the Poles the Infusoria are still met with in myriads; many species were observed in the Antarctic Seas during the voyages of Captain Sir James Ross. In the residuum of the blocks of ice floating about in latitude 78° 10′, nearly fifty different species were found. In many of them, according to Ehrenberg, the contents were still green, which proved that they had struggled successfully with the rigours of the climate in searching for food.

Humboldt asserts that, at a depth which exceeds the height of the loftiest mountain, every portion of the bottom of the sea is animated by an innumerable phalanx of inhabitants quite imperceptible to the human eye. These microscopic creatures are, in short, the smallest and among the most numerous creations in Nature. They constitute, with human beings, one of the wheels of that very complicated machine, the globe. They are in the rank and at the station willed for them, as determined in the great First Thought. Suppress these microscopic beings, and the world would be incomplete. It was said, and wisely said, long, long ago, "there is nothing so small to the view but that it may become great by reflection."

The Infusoria, in short, abound everywhere. We find their remains on the loftiest mountain ridges, and in the profoundest depths of the sea. They increase and multiply alike under the Equator, and towards the polar regions. The seas, rivers, ponds—the flower vase which rests upon the casement—even our tissues, and the fluids of our bodies—may all contain infusorial animalcules. Whole beds of strata, often many feet thick, and covering a surface of considerable extent, are to be met with almost exclusively formed of their accumulated débris. It is to the Infusoria that the mud of the Nile and other fluviatile and lacustrine deposits are said to owe their prodigious fertility. To them also is sometimes due the red or green colouring matter to be found in ponds and tanks at certain seasons. When water is exposed to great solar heat, in order to extract the salt from it—as it is in the vast artificial basins hollowed

out for the purpose in the salt marshes near the sea-shore in the south of France and elsewhere—the salt water often reaches a very high degree of concentration, and is then found to acquire a fine rose colour, which is due to the presence of innumerable masses of small Infusoria or Crustacea having a reddish hue. At one time it was thought that the Tripoli stone was formed of tens of millions of the cases of Infusoria; but it is now known that this stone contains vast masses of sponge spicules and Diatomaceæ.

The study of these creatures is intensely interesting to the naturalist, the philosopher, the physician, and the general reader. They have had a great part assigned to them in Nature, as is evident in the formation of certain beds of rock of immense extent, in which the geologist traces their action.

Our earliest knowledge of the Infusoria is traceable to the seventeenth century. In 1752 Hill essayed the first attempt at their classification. In 1776 O. F. Müller gave them the name of Infusoria, because he found them in such great abundance in animal and vegetable *infusions*. To the celebrated naturalist Leuwenhoek we are indebted for much information about them. Müller published a special book upon them.

From that time the Infusoria have been considered as forming a special group among the Protozoa; afterwards, in the pages of von Baer and of De Blainville, we see that they regarded these creatures, so imperfect in appearance, as only the indeterminate prototype of other classes. But ideas changed altogether respecting them when microscopes well supplied with achromatic lenses were employed in their study. Thanks to the labours of Ehrenberg and Dujardin, Stein and Claparade, we have now arrived at a better comprehension of the organisation of these infinitely small beings; and naturalists have established, with more exactness, the limits of the zoological group to which they belong.

Some waters are so filled with Infusoria that it is only necessary to dip at random into the liquid medium to procure them in abundance. In other waters they form a stratum, occupying the whole basin. In general, however, it is necessary to search for them where the water is calm, and filled with vegetation of some kind, such as *Confervæ*, or *Lemna*, &c., in the marshes, and *Algæ* if in the sea. Certain Infusoria live not only in water, but also in places habitually moist, as among tufts of mosses, on moist soil, or on damp walls. Others live as parasites on the exterior or sometimes in the interior of animals.

But, as their name indicates, they will be found in all aqueous

infusions, vegetable or animal. With the assistance of a microscope the reader may, with very little trouble, afford himself the pleasure of studying these animals. It is only necessary to place some organic débris—the white of an egg, or some chopped hay, for example—in a bottle with a large mouth, filled with water, and expose it to the light and air, and it will be found in the course of a few days to swarm with infusorial life. Certain reagents, as phosphate of soda, the phosphates, nitrates, or oxalates of ammonia, or carbonate of soda, added to these infusions, favour the development of Infusoria.

So much for the medium in which they live, move, and have their being. Let us pass on to their organisation. We have already dwelt on their extreme minuteness; their mean size may be the fifth of a line, or the sixtieth part of an inch; the largest species scarcely reveal themselves to the naked eye. They are generally colourless; some of them are, nevertheless, green, blue, red, brown, and even blackish. Seen under the microscope, they appear either transparent and naked, or invested with an envelope more or less resistent, which is homogenous, diaphanous, elastic, contractile, and apparently destitute of every kind of organisation. They are of every imaginable shape. Some of those most frequently met with, and which from their size attract the most attention from observers, are furnished with *vibratile cilia*, which either cover the whole body, or are attached to certain portions of it, acting as paddles. These organs are evidently intended to propel the animal from one place to another, while at other times certain of them appear to be employed in conveying food to the mouth. Some Infusoria are without these cilia, having only one or many very slender filaments or *flagella*, the undulating movement of which suffices to determine their progression through the liquid which surrounds them.

Authors who have written on the Infusoria have sometimes, like Leuwenhoek and Ehrenberg, attributed to them a very complex structure. Others, like Müller, Cuvier, Claparade, Lamarck, Stein, and all recent writers, have considered them to be gifted with an organisation extremely simple.

Some of the species are indeed of very lowly organisation; while again many of them are among the most highly organised of the Protoza, for here we find the first appearance of a well differentiated alimentary system. Indeed, the digestive system of the Infusoria has been the subject of numerous observations, and was at one time the subject of very animated discussions. In the inferior members of the class, which comprehends the very smallest animalcules, it has not

indeed been found possible to observe the organisation of the digestive system in a satisfactory manner. Some writers think they have no mouth, what has been taken for that organ being only a hollow dimple on the surface of the body; others recognise the existence of an oral orifice or mouth, sometimes specially furnished.

The digestive system is better understood in the superior Infusoria, called the *ciliate Infusoria*, namely, those provided with *vibratile cilia*. These cilia seem to determine the currents which convey the numerous nutritive corpuscles suspended in the water towards the entrance of the digestive system. They form, in some sort, the prehensile organs which seize the aliment.

The minute particles of food thus directed towards the oral orifice by the vibratile cilia are soon engulfed by the mouth and speedily disappear into the interior of the animal. Availing himself of this fact, and of the transparency of these creatures, Gleichen, a German physiologist of the last century, conceived the happy idea of colouring the water which contained Infusoria with finely-powdered carmine, and he thus traced the colouring matter into the bodies of some of them. But it was reserved for Ehrenberg to avail himself of the same artifice in order to study more in detail the internal structure of these minute creatures, as well as their mode of absorbing nutritive matter. This physiologist fed many groups of Infusoria, some of them with water coloured with carmine, others with indigo and other colouring matters; the coloured particles were greedily swallowed, and were thought to show the arrangement and disposition of the alimentary system, for he arrived at the conclusion that, as the colouring matter was deposited in apparently perfect cavities, so each of these cavities was a stomach, and that the passage of the food into each of these reservoirs was effected by means of an intestinal tube, around which these stomachs were arranged. In some cases he even thought he could distinguish, and again in others he figured, the outlines of this intestinal canal, and showed its connection with numbers of the little bladder-like stomachs. We now know that his class Infusoria embraced two very different forms of animal life, the *Polygastrica* and *Rotifera*, the latter division including the well-known Wheel animalcules; the *Polygastrica* being so called from his idea that the typical forms possessed a number of stomachs. That Ehrenberg recognised a difference between them is apparent from his division; but the organisation of the *Rotifera* remove them very far indeed from the true Infusoria.

Other observers were not slow in raising objections to these views of Ehrenberg. Dujardin, especially, did not believe in the complex

alimentary system attributed to these creatures by the German physiologist. He laboured to establish the fact that the coloured globules which appeared in the bodies of the Infusoria, while subjected to a regimen of carmine and indigo, are not confined by a membrane; that is to say, they are not contained in special alimentary sacs, and that these so-called stomachs are, as stated by Milne-Edwards, "nothing but a species of reservoirs, constituted," as he says, "by the alimentary matter with which each is gorged, united into a rounded pasty mass, so that it could no longer be dispersed, but would continue to advance, still preserving its form. We have, in short, seen these spherules changing their places, and passing one another in their progress from the mouth through the intestinal canal. That they could not do this is evident, if many stomachs were attached to the intestinal canal!"

This opinion, due to the patient and precise studies of Dujardin, has been adopted by most naturalists of eminence. Besides, this learned microscopist does not admit that there was in the sarcodic mass of Infusoria any pre-existent special alimentary cavity destined to receive the food. In a word, he does not recognise in them any true stomach whatever. This view of the extreme simplicity of structure in the Infusoria has, however, met with opposition even by some recent writers. To accord them neither four nor two stomachs, it is not necessary to deprive them of the organ altogether. Meyen represents them as having one great hollow stomach occupied by a pulpy matter, into which the alimentary masses are successively absorbed. "All recent observations," says Milne-Edwards, "tend to establish the fact that the digestive apparatus of the ciliate Infusoria consists of—first, a mouth; second, of a pharyngeal canal, in which the food often assumes the form of a *bolus;* third, of one great stomach with distinct walls, and more or less distant from the common tegumentary membrane; fourth, of an excretory orifice."

This mouth presents sensible differences, both as to its position and conformation, often occupying the bottom of a hollow, the edges of which are furnished with well-developed *cilia*, the action of which attracts the aliment; in short, the mouth is a sort of decoy at the bottom of a simple pit, being at once contractile and prehensile, the interior part being sometimes capable, according to Milne-Edwards, of being turned inside out in the form of a trumpet, while in a great many species it is provided with a peculiar armature, consisting of a band of rigid bristles disposed in the form of a bow-net, and susceptible of dilatation and contraction, according to the wants of the animal. The œsophagus, which is connected with the mouth, has

generally an oblique direction backwards, often terminating in a great undivided stomach.

The reproduction of the Infusoria exhibits some very surprising phenomena, while it offers another proof of the wonderful means Nature employs for perpetuating the races of animals. They can be reproduced by three different processes:—1. By gemmation, or budding, somewhat after the manner of plants. 2. By the spontaneous division of the animal into two individuals—a process known to zoologists as fission. 3. By sexual reproduction; for in these little creatures it has recently been discovered that sexual differences exist.

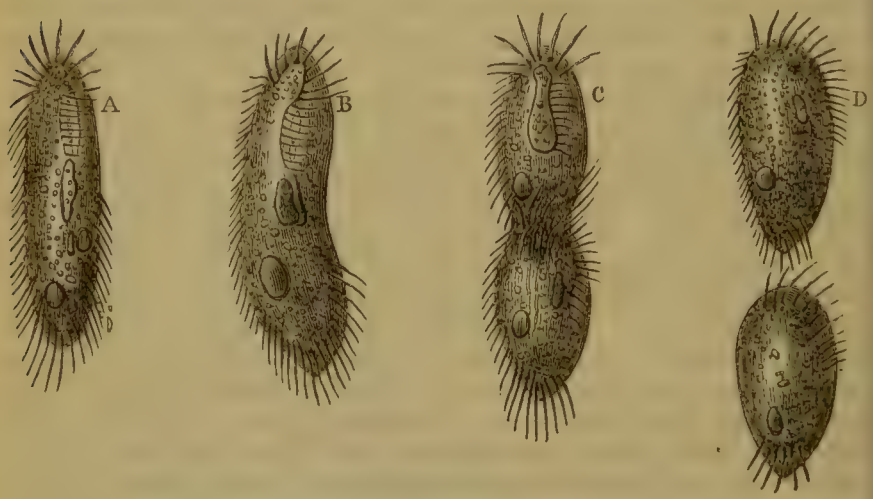


Fig. 27.—Propagation of an Infusorian by spontaneous division.

The singular phenomenon of spontaneous division may be witnessed by any one having patience to examine the creature long enough, isolated from its innumerable companions, under the microscope. The oblong body of the animal may be observed to contract at the middle, the compression becoming more and more marked. The lower segment soon begins to show at the place of construction a few vibratile cilia, thus indicating the place which will soon be a new mouth; this organ soon becomes more and more distinct, and now the Infusorian literally divides itself into two parts. The two halves separate from each other very quickly, each moiety having a perfect resemblance to the form which gave them origin, and both swim about with all the activity of perfect life. This process is represented in Fig. 27, A and B being the adult, C the same in course

of separation, D after its completion. Assuredly this is one of the most remarkable phenomena which the study of living beings can present. "By this mode of propagation," says Dujardin, "an Infusorian is the half of the one which preceded it, the fourth of the parent of that, the eighth of its grand-parent, and so on, if indeed we can apply the terms father or mother to animals which must see in its two halves the grandfather himself by a new division again living in his four parts. We might imagine such an Infusorian to be an aliquot part of one like it, which had lived years, and even ages before, and which by continued subdivisions into pairs might continue to live for ever by its successive development."

This mode of generation, however, enables us to comprehend the almost miraculous multiplication of these beings. The amount defies calculation, if we wished to be at all precise. We may, however, arrive at a proximate estimate of the number which may be derived from a single individual by this process of fission. It has been found that at the end of a month two *Stylonichiæ* would have a progeny of more than 1,048,000 individuals, and that in a lapse of forty-two days a single *Paramecium* could produce more more than 1,364,000 forms like itself.

The prodigious number to which they would reach, if we were to add the other modes of propagation, viz., by germs and by budding, we dare not calculate; it would only be necessary to place a single germ of one of these microscopic animalcules in a favourable condition for its development, in order to produce myriads of them in a very few days.

We have seen three modes of reproduction in the Infusoria; it is considered by some possible that a fourth mode exists, to which its partisans give the name of *spontaneous generation.* According to their views, an Infusorian can be produced, without egg-germ or pre-existent parent. It is quite sufficient, they say, to expose organic matter, animal or vegetable, to the action of the air and water at a suitable temperature, in order to see this matter organise itself, and form itself into living infusorial animals.

Such is the general theory of spontaneous or heterogeneous generation, on which so much has been written within the last ten years. Amongst great investigators of this theory have been the two French naturalists, MM. Pouchet and Joly. Their views have, however, made little progress; they have, on the contrary, met with vigorous opposition from the generality of French naturalists, and from most of the members of the Academy of Sciences of Paris, who have raised their voices against a doctrine which, however possible, is

certainly not yet demonstrated. In short, the direct observations made upon the theory of "primitive generation" are as yet wanting in the necessary exactness; those observers who profess to have witnessed the sudden origin of the minutest of the Infusoria from elementary substances have in all probability overlooked the presence of very minute organic germs in or among those elementary bodies.

Many of the Infusoria are subject to metamorphoses; and it has already been ascertained that certain species which have been considered as distinct are only transitional forms of the same species depending on age.

We know that it is common for insects to enclose themselves in protecting envelopes, and to remain for whole months shut up in this their retreat, to all appearance dead. Similar facts have been observed in the Infusoria, and indeed are intimately connected with their development. Some of them, previously to undergoing fission, become coated with a secretion of gelatinous matter, which gradually hardens so as to enclose the body in a "cyst." We have even seen some of these beings surrounding strange bodies, as if in a mass of jelly, forming a sort of living envelope around them.

Certain species present, in relation to the tenacity of life, phenomena which are only imperfectly known, but which will never fail to excite the surprise and admiration of the naturalist. By drying certain infusoria with care, it is found possible to suspend and indefinitely prolong their life. Thus dried, these Infusoria may and are without doubt carried to great distances, for even an indefinite period of time, and then abandoned on some ledge of rock, on a housetop, in the cleft of a wall, or under the capital of a column, lie there undisturbed; but let a drop of water approach it, and the dormant being awakes immediately—the microscopic Lazarus springs again into existence, feeds and multiplies as before, and its life, suspended possibly for years, resumes its interrupted course!

Into what a world of reflection does not a revelation of this mysterious property of a living creature plunge us!

The physiologist Müller has noted another peculiarity in infusorial life. These animalcules can lose a part of their bodies without being destroyed; the dead part disappears, and the individual, diminished by one-half or reduced to a fourth of its former size, continues to live as if nothing had happened. Müller has observed an Infusorian (*Amphileptus meleagris*) thus melt before his eyes until scarcely a sixteenth part of its body remained. After its loss, this sixteenth part of an animal continued to swim about without troubling itself as to its diminished proportions. "The Infusoria," says Frédol, in "La

Monde de la Mer," "present yet another kind of decomposition. If we approach the drop of water in which one swims with the barb of a feather dipped in ammonia, the animalcule is arrested in its movement, but its cilia continue to move rapidly. All at once, upon some point of its circumference, a notch is formed, which increases bit by bit until the whole animal is dissolved. If a drop of pure water is added, the decomposition is suddenly stopped, and what remains of the animalcule recommences its swimming movements." (Dujardin.)

Life is spread over Nature in such abundance that the smallest

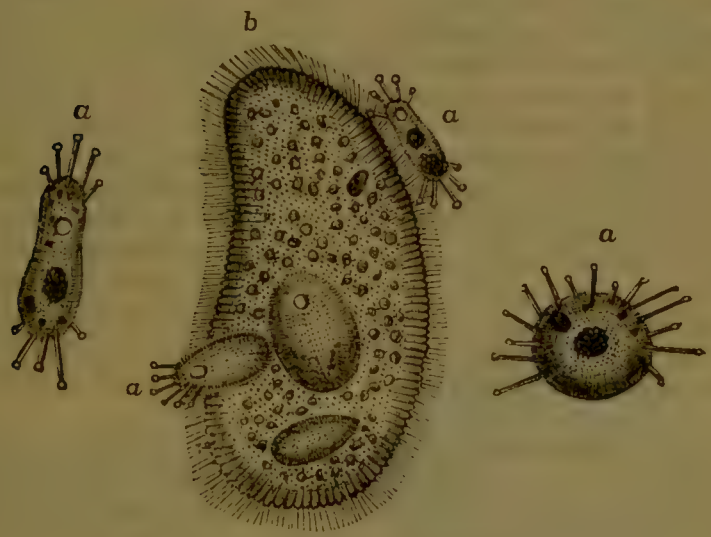


Fig. 28.—Paramecium aurelia and its Parasites.

Infusorian has often as its parasite a creature still smaller; these in their turn serving as "a dwelling and pasture ground," to use Humboldt's words, for still smaller animalcules, as represented in Fig. 28—*a* being parasites in various stages of development; *b*, the larger animalcule on which they have established themselves.

The Infusoria may be divided into two groups—the *Flagelliferous Infusoria*, those, namely, which are provided with flagella, and the *Ciliate Infusoria*, namely, those provided with vibratile cilia. The greater number of the Infusoria belong to the first group, which comprehends many families; our space limits us to the mention here of a few typical forms only in each group, selecting those which

appear the most interesting, from their size, structure, rarity, or abundance.

Included among these, but, according to Cohn, apparently belonging to the vegetable kingdom, we find the family of *Vibrionidæ*, so named from their darting or quivering motion, including the eel-like microscopic animalcules which occur in stale paste, vinegar, &c., with some others, which are parasitic on living vegetables, such as *Vibrio tritici*, which infests the grains of wheat, producing the destructive disease called corn-cockle or purples. They are filiform, extremely slender, without appreciable organisation or apparent organs of locomotion. They are among the first organisms which show themselves in any infusion of organic matter. By using microscopes of the highest magnifying power, they present the appearance of very thin short lines, either straight or sinuous, the thickest of them not exceeding the thousandth part of the fraction of an inch. They are contractile, and propagate by spontaneous fission, often imperfect in character, and hence giving rise to chains of greater or less length. Among them some resemble right lines, more or less distinctly articulated, and endowed with a very slow movement, these are *Bacteria:* others are flexuous and undulating, and more or less lively; these are true *Vibrios;* others have the body fashioned in the form of a corkscrew, turning unceasingly upon themselves with great rapidity, these are the *Spirilla*, having an oblong fusiform or filiform body, which undulates or turns spirally upon itself.

The *Bacterium termo* (Fig. 29) is one of the smallest of these organisms, and is, according to Cohn, the motile phase of an alga. It is found, at the end of a short time, in all vegetable or animal infusions exposed to the air. It shows itself in infinite numbers, forming perfect swarms, which disappear as other species multiply in the liquid, to which it serves for nourishment. When the infusion becomes too fœtid for these new species to live in it, in consequence of fermentation or putrefaction, the *Bacterium termo* reappears. This species was one of the first observed; Leuwenhoek found it in the white matter which is called teeth tartar, and which is met with in the teeth and gums. It is also found in the fluids of various animals which have been affected by disease.

The *Wand-like Vibrio* (Fig. 30) has the body transparent, filiform, and long articulations, often appearing as if broken at each connection. It moves very slowly in the water. Leuwenhoek observed this second species joined to the first in the teeth tartar, and also in a great number of organic infusions.

"There is no microscopic object," says Dujardin, "which excites the admiration of the observer more vividly than the twisting Spirillum" (Fig. 31). He was struck with surprise when he first contemplated this little creature, which, under very high magnifying

Fig. 29. Bacterium termo (Müller), magnified 600 times.

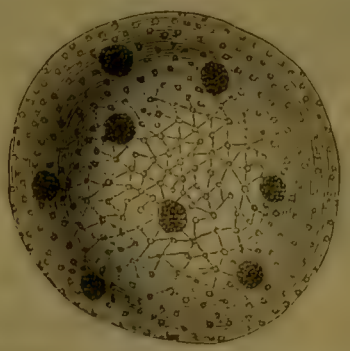
The same, magnified 1,600 times.

Fig. 30. Vibrio (Müller), magnified 300 times.

Fig. 31. Spirillum (Ehr.), magnified 300 times.

powers only presents the appearance of a thin black line, fashioned like a corkscrew, which every instant turns upon itself with marvellous velocity, so that the eye can scarcely follow it.

The *Volvocineæ* were also at one time included among the flagel-



Figs. 32 and 33.—Volvox globator (Müller), magnified 700 times.

late Infusoria, but now are more generally believed to belong to the vegetable kingdom, they are met with in fresh water full of Confervæ and other aquatic plants. The *Volvocineæ* are of a green or yellowish brown colour, with 300 spore-like bodies regularly disseminated in the thickness and near the surface of a gelatinous hollow globe. In this state, from five to eight smaller globules, with the same organisation, appear destined to undergo the same changes when they are released

by the rupture of the globule. These are each furnished with one or two flagelliform filaments, which, by their agitation, determine the movement by rotation of the mass.

The common Volvox, *V. globator* (Figs. 32 and 33), is found in great abundance, during summer and even in the depth of winter, in lakes and ponds of fresh water. It consists of green or brownish-yellow globules about the thirtieth part of an inch, formed of monadiform beings scattered round a gelatinous and diaphanous spherical disc, each furnished with a flagelliform filament and with a reddish interior point, which Ehrenberg took for an eye. Leuwenhoek first observed this Volvox in marshy waters. This eminent naturalist has left a very interesting account of his observations on these microscopic creatures, displaying an amount of patience and address which cannot be too much admired; his observations were made with a simple lens, which he constructed himself. In one hand he held his instrument—which was very coarse if we compare it to the more perfect and infinitely more powerful instruments now in use—whilst, in the other hand, he carried to it the glass tube full of water which contained the objects under observation. "The microscopes of Leuwenhoek," says Dujardin, "were bi-convex lenses of the very smallest size, mounted in a silver frame-work. He made a collection of twenty-six, which he bequeathed to the Royal Society of London. These instruments, subject to all the inconveniences of a maximum of spherical aberration and a total want of stability, were only fit for use in the hands of Leuwenhoek himself, who had acquired, by his labours of twenty years, habits of observation which compensated, in great part, for the want of perfection in his instruments." We now come to those forms considered as belonging to the

Flagellate Infusoria.

The *Monads* are infusorial animalcules which make an early appearance in vegetable infusions. They constitute a family that are destitute of any tegumentary covering. The substance of their bodies can shorten itself, or draw itself out more or less; their whip-like filaments serve as organs of locomotion. Their organisation is extremely simple; their whip-like filaments are so fine as to be scarcely perceptible, their length is sometimes double and even quadruple the length of the animal itself.

The *Lens Monad* (Fig. 34) is a species which is frequently met with in vegetable and animal infusions. The older microscopists had it indicated under the form of a globule, moving in a slow and

vacillating manner. The globule is formed of a homogeneous transparent substance, which throws out obliquely a whip-like filament, three, four, or even five times the length of the body of the Monad.

The genus *Cercomonas* of Dujardin has its body pyriform, having in front a vibratile filament, very long, very flexible, and easily agitated. Behind the body there is a thicker straight filament attaching itself sometimes to neighbouring corpuscles, round which, in this case, the *Cercomonad* oscillates like the ball of a pendulum round its stem.

Fig. 34. Monas lens Dujardin), magnified 1,000 times.

The *Euglenæa* are infusoria usually of a green or red colour. Their form is very variable. They are oblong or fusiform in shape, swelling at the middle during locomotion, and contracted or bowl-shaped in repose, or after death. They are furnished with the usual whip-shaped filament, which issues from an opening in front, and possess one or many reddish points irregularly placed anteriorly.

Euglena viridis (Fig. 35) is the most common species, and among the most widely diffused of all the Infusoria. It is this animalcule which is often met covering stagnant pools with a floating surface of green, and which forms on the surface of marshy waters the shining pellicle so strongly coloured, which, collected upon paper, so long preserves its brilliant tint.

The *Euglena sanguinea*, at first green, becomes subsequently of a blood colour. It has often been met with by microscopists. Ehrenberg, who first described it, attributes to its great abundance the red colour of some stagnant waters. Its presence may perhaps explain the pretended miracle of water changing into blood, which was frequently invoked by the Egyptian priests.

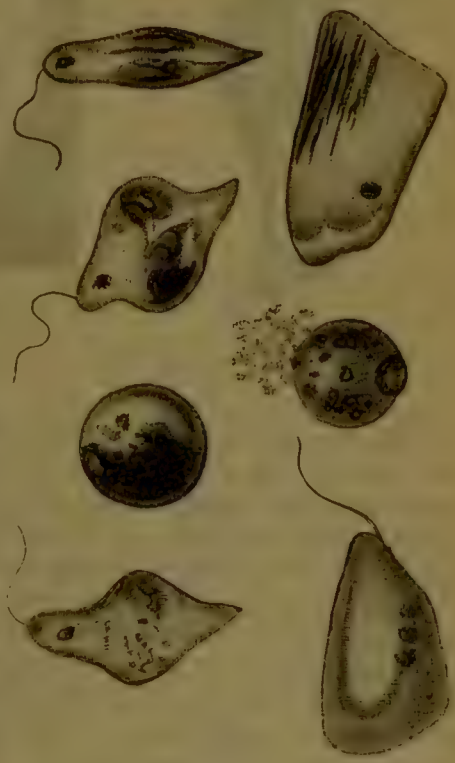


Fig. 35. Euglena viridis (Ehr.), magnified 350 times.

Ciliate Infusoria.

Let us now take a glance at some of the more remarkable species of Ciliate Infusoria. The bodies of these creatures are all more or less translucent. Many of them have not consistence enough to reach a state of opacity. Their bodies are more or less globular or ovoid, sometimes fashioned like a shuttle, sometimes swollen in the middle like an ampulla, sometimes they are bell-shaped, and again they are often found flattened into a discoid shape.

Fig. 36.
Cothurnia pyxidiformis (Udekem).

Fig. 37.
Paramecium bursaria (Pritchard).

The Paramecians have a soft flexible body, usually of oblong form, and more or less depressed. They are provided with a loose reticulated covering, through which issue numerous vibratile cilia, arranged in a regular series (Fig. 37). They were known to the older naturalists; and it is in this group that organisation is carried to the highest perfection it attains among the Infusoria. The Paramecium possess, besides their reticulated and contractile tegument, cilia disposed in such a manner as to serve at once for locomotion, and for prehension that is, for the seizing of food. They are furnished with a mouth, at the bottom of which lies a cavity, formed after the manner of a cul-de-sac, in which lies enclosed the substances which the Paramecium have swallowed along with the water.

The Paramecians are propagated by spontaneous division, as already described. They abound, as we have said, in semi-stagnant water, or in pure water which is occupied by aquatic plants, sometimes in such prodigious quantities that they become troublesome. They may occur also in flower vases where the water is not frequently renewed.

The species of this genus have an oblong compressed body, with an oblique longitudinal fold, directed towards the mouth, which is lateral. They are sufficiently large to be observed with a common lens, or eye-glass. *Paramecium aurelia* is common in ditches, or ponds, and moats, with aquatic plants.

Humboldt's assertion is fully verified in the case of the Infusorian under consideration, which is often found with its parasites (*vide* Fig 28). These are small creatures, cylindrical in form, and provided with suckers. Swimming vigorously in the water, they devote themselves to chasing the Paramecium. When they have overtaken the fugitive, they throw themselves upon it, and establish themselves there. They soon multiply in the interior of its body, and their progeny suck and devour the unfortunate animalcule, which thus serves them at once for dwelling-house and larder.

Another of the parasites which prey upon the Paramecium, in place of pursuing it, remains perfectly quiet until one of these approach, when it throws itself upon its victim, and is carried along with it. It buries itself in the body of the Paramecium, and, in a short time, multiplies to such a degree, that sometimes fifty of them are found on a single individual.

The species of the genus *Nassula* have the body entirely covered with cilia ; they are ovoid or oblong in form, contractile, their mouth is placed laterally, and provided with a circlet of teeth in the form of a wheel (*nassa*), this circlet dilating and contracting according to the size of the prey which it would swallow. They will either advance to seize the prey, which the movement of the vibratile cilia have failed to draw within the vortex of their mouth, or, as in the case of the Paramecium, they are sometimes obliged to seek for their prey. These curious Infusoria live in fresh water, feeding on the débris of aquatic plants, from which they draw their chief nourishment. Their colour is white or greenish, sometimes a brownish green, variegated with violet vesicles.

The genus *Bursaria* contains animals with an oval or oblong contractile body, provided also with vibratile cilia on the surface, having also a large mouth, surrounded with cilia, forming a sort of microscopic moustache, spirally arranged.

Among the forms closely related to this group may be noted the *Kondylostoma patens* (Fig. 38), remarkable for its size and voracity. It sometimes attains to thesize of the twelfth of an inch, and abounds on every shore from the Mediterranean to the Baltic, living among algæ. Another Bursarian, a species called *Lumbrici*, lives between

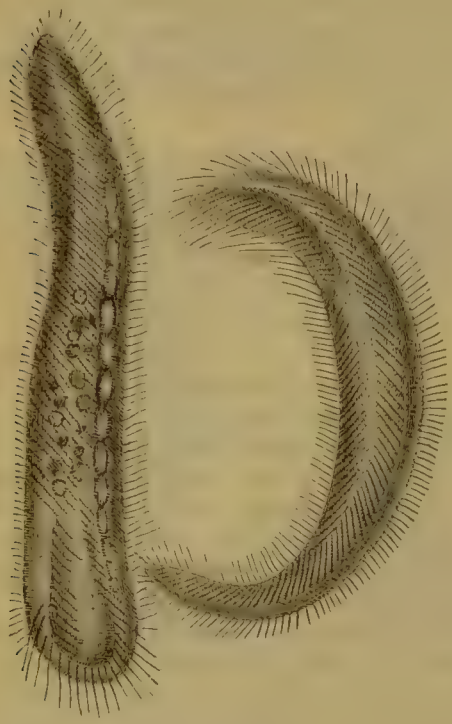


Fig 38.—Kondylostoma patens (Duj.), magnified 350 times.

Fig. 39.—Stentor Muelleri (Ehr)

the intestines and the external muscular coat of the earth-worm, *Lumbricus terrestris*.

To the group of *Vorticellina* belongs the genus *Stentor*, some species of which are quite perceptible to the naked eye.

The Stentors are inhabitants of fresh, tranquil water, not subject to agitation, and covered with water plants. They are nearly all coloured green, blackish, or blue; their bodies are covered with cilia. They are eminently contractile, and very variable in form. Their body is without a stalk, but they can attach themselves temporarily by means of the posterior extremity of their body; they

can assume a trumpet-like form, the bell of which is closed by a convex membrane, the edge being furnished with a row of very strong obliquely-placed cilia, ranged in a spiral, meeting at the mouth, which is placed near this edge. When they swim freely, their body admits of very considerable modifications of form. The *Stentor Muelleri* (Fig. 39) is to be found in ponds everywhere, often freely swimming in vast multitudes, or, again, attached in dense patches to some aquatic plant.

Some of the animals which belong to the *Vorticellina* are fixed during one part of their existence, and become free in another stage. So long as they are fixed, they resemble, in their expanded state, a bell or funnel, with the edges reversed and ciliate. When they become free, they lose their crown of cilia, take a cylindrical form, more or less ovoid and elongated, and move themselves by means of a new row of a posterior circlet of cilia, which is temporarily developed. "There is no animal," says Dujardin, "which excites our admiration in a higher degree than a vorticellate Infusorian, by its crown of cilia, and by the vortex which it produces; by its ever-varying form; above all, by its pedicle, which is susceptible of rapid spiral contraction, drawing the body backward, and again extending it." This pedicle is remarkably contractile, drawing itself into a close coil with extraordinary rapidity, and again uncoiling itself with equal quickness. It is a hollow tube, containing a thread or band within it, to which its great contractile power is due. The genus Cothurnia belongs also to this group (Fig. 36).

We cannot conclude our brief history of these curiously-organised beings without again recording the doubt which still exists in the minds of our most eminent naturalists, whether some of them are, as we have before mentioned, animal or vegetable in their origin. The *Desmideæ*, long classed among animals, are now generally recognised as plants; so also the group of the *Diatomaceæ*. The Monads and *Volvocinea* are still subjects of discussion, the evidence apparently inclining in favour of those who argue for their vegetable nature. Messrs. Busk, Williamson, and Cohn, have published, in the *Microscopical Transactions*, minute details of the evolutions of these curiously-organised Volvocinea, which seem to prove their vegetable nature. On the other hand, it is somewhat difficult to imagine so accurate an observer as Agassiz writing so positively as he does on a doubtful subject, unless he had a very firm conviction as to the truth of his observations. Remarking on a former paper, in which he had shown that the embryo hatched from the egg of a Planarian was a true polygastric animalcule of the

genus Paramecium, he adds, that in former writers a link was wanting, viz., tracing the young actually hatched from the egg of a Planarian. "This deficiency," he says, "I can now fill. It is another *Infusorium*, a genuine *Opalina*. With such facts before us, there is no longer any doubt left respecting the character of all these Polygastria; they are the earliest larval condition of worms."

CHAPTER V.

CŒLENTERATA.

"Happy is he, who, satisfied with his humble fortune, lives contentedly in the obscure state where God has placed him."—RACINE.

ENTERING on the sub-class of the Cœlenterata, we leave the domain of the infinitely small to enter on the examination of somewhat larger beings. In comparison with the Infusoria, the Cœlenterata, which are sometimes of large size, are very important beings. Science lately has made great advances towards giving us an exact knowledge of the history of these singular animals. Many scientific prejudices have been dissipated, many errors have been corrected. The Cœlenterata, as they are defined in the actual state of Science, correspond not only with the Polypes, properly so called, of Cuvier and De Blainville, but also with the Acalephæ of the same authors. We now know that certain of the Cœlenterata give origin to Medusæ; and that the great majority of the organisms described as such are in reality the detached reproductive bodies of certain Cœlenterates.

Thus regarded, the Cœlenterates comprehend a great variety of animals, the bodies of which are generally of a soft or gelatinous substance. The alimentary canal freely communicates with the general cavity of the animal's body; there is no distinct blood system; a nervous system is absent in most; and peculiarly-constituted urticating organs are almost invariably present. They are invested with a skin or integument, which sometimes secretes peculiar calcareous bodies, and even a portion of the deepest-lying tissues may be invaded by a calcareous deposit, the mass of which belongs sometimes to an individual; sometimes it is common to many, constituting what Dr. Johnston calls the Polypidom, of which Professor Grant says, "there is but one life and one plan of development in the whole mass, and this depends, not on the polyps, but on the general fleshy substance of the body:"* "the ramifications of the polypidom," says Dr. Johnston, "are often disposed in a variety of elegant plant-like forms. The

* "Outlines of Comparative Anatomy."

stem and branches are alike in texture: slender, horny, fistular, and almost always jointed at short and regular intervals, the joint being a mere break in the continuity of the sheath, without any character of a proper hinge, and formed by regular periodical interruptions in the growth of the polypidoms. Along the sides of these, or at their extremities, we find the denticles or cup-like cells of the polyps arranged in a determinate order, either sessile or elevated on a stalk." Near the base of each of these there is a partition or diaphragm, on which the body of the polyps rests, with a plain or tubulous perforation in the centre, through which the connection between the individual polyps and the common medullary substance is retained. Besides the polyps, there are found at certain seasons a number of reproductive bodies, called *gonophores*, readily distinguished from the polyps by their size, and the irregularity of their distribution, which are destined to contain and mature the ovules.

With these animals the digestive tube is very simple, and presents only one distinct orifice; the same opening serving at once for receiving the food and the expulsion of the residuum of digestion, as will be so easily seen in the common sea anemone.

In nearly all the Cœlenterata the sexes are separate; the generation is sometimes sexual; but these beings multiply also by what zoologists call gemmation, or budding. Some are provided with supposed organs of sense; many of the swimming forms having eye-like marginal bodies—a progress in organisation as compared with the animals which have hitherto engaged our attention. Vibratile cilia often cover the entire surface of the Polyps, and their tegumentary system is richly supplied with thread cells.

These general remarks may appear obscure and insufficient to the large number of our readers. They are necessarily so; they are at best but generalities upon an interesting group of animals. We quit them, trusting to make the special study of the several classes we shall have to describe more interesting.

The sub-kingdom Cœlenterata naturally divides itself into two groups—that of the *Hydrozoa*, and that of the *Actinozoa*. The pretty fresh-water Hydra will serve as an example of the first, and the common sea anemone of the second group. The essential difference between the two is, that in the former the stomachal cavity is not separated from the general cavity of the body, and the reproductive buds are external; while in the latter the stomachal cavity is let down, as it were, as a partially-closed sac, into the general cavity of the body; and the reproductive buds make their appearance between the walls of the general cavity and the alimentary

or stomachal sac, and consequently internally. But in both there is a free communication between these two cavities—a communication obvious in the Hydrozoa, and which may be often verified in the case of the sea anemones, by the young anemones making their appearance at the mouth of the parent anemone, having first escaped from the general cavity out into the alimentary cavity of its body.

The Hydrozoa contains no less than seven orders, which will be referred to in our next chapter (VI). The Actinozoa contain three recent orders: the Zoantharia (Chapter VII), the Alcyonaria, and the Ctenophora (Chapter VIII).

CHAPTER VI.

HYDROZOA.

"In nova fert animus mutatis dicere formas corpora."—OVID, *Met.*

THE class Hydrozoa includes the Acalephæ (from ἀκαλήφη, a nettle, so called from the stinging properties which many of them possess), as well as a great number of radiate animals, of which the Medusæ are the type. Many of them are remarkable as floating and swimming in the sea by means of the contraction and dilatation of their bodies, their substance being gelatinous, without apparent fibres; many of them, again, are attached and are only locomotive in their young state.

The great order of the Medusidæ is characterised by having a disc, more or less convex above, resembling a mushroom or expanded umbrella, the edges of the umbrella, as well as the mouth and suckers, being more or less prolonged into pedicles, which take their place in the middle of the lower surface; they are furnished with tentacula, varying in form and size, which have given rise to many subdivisions, with which we need not concern ourselves.

The substance of the disc presents a uniform cellular appearance internally, but the cellular substance being very soft, no trace of fibre is observable. Taken from the sea, and laid upon a stone, a Medusa weighing fifty ounces will rapidly diminish to five or six grains, sinking into a sort of deliquescence, from which Spalanzani concluded that the sea-water penetrated the organic texture of its substance, and constituted the principal volume of the animal. Those which have cilia round their margins have also cellular bands running along their bases, and most of the projectile and extensile tentacula and filaments have sacs and canals containing fluids at their roots. The indications of nerves or nervous system are too slight to be received as evidence, although Dr. Grant observed some structures which he thought could only belong to a nervous system, and Ehrenberg thought he observed eyes in *Medusa aurita*, as well as a nervous circle formed of four ganglion-like masses disposed round the

mouth. But most naturalists seem to be of opinion that touch is the only sense of which any conclusive proof can be advanced.

Here we behold a class of bell-shaped semi-transparent organisms, which float gracefully in the sea—a great family of soft, wandering animals, constituted in a most extraordinary manner. They look like floating umbrellas, or, better still, floating mushrooms, the footstalk replaced by an equally central body, but divided into divergent lobes at once sinuous, twisted, and fringed, so that one is at first tempted to take them for a species of root. The edges of the umbrella or mushroom are entire or dentate, sometimes elegantly scolloped, often ciliate, or provided with long filiform appendages which float vertically in the water.

Sometimes the animal is transparent, and limpid as crystal; sometimes it presents a slightly opaline appearance, now of a tender blue, or of a delicate rose colour; at other times it reflects the most brilliant and vivid tints.

In certain species the central parts only are coloured, showing brilliant reds and yellows, blues or violets, the rest being colourless. In others the central mass seems clothed in a thin iridescent or diaphanous veil, like the light evanescent soap-bubble, or the transparent glass shade which covers a group of artificial flowers.

The Medusæ are animals without much consistence, containing much water, so that we can scarcely comprehend how they resist the agitation of the waves and the force of the currents; the waves, however, float without hurting them, the tempest scatters without killing them. When the sea retires, or they are withdrawn from their native waters, their substance dissolves, the animal is decomposed, they are reduced to nothing; if the sun is strong, this disorganisation occurs in the twinkling of an eye, so to speak.

When the Medusæ travel their convex part is always kept in advance and slightly oblique. If they are touched while swimming, even lightly, they contract their tentacula, fold up their umbrella, and sink into the sea. Like Ehrenberg, M. Kölliker thought he discovered visual and auditory organs in an *Oceania*, and Gegenbauer thought he detected them in other genera, such as *Rhizostoma* and *Pelagia*. The eyes are said to consist of certain small, hemispherical, cellulose, coloured masses, in which are sunk small crystalline globules, the free parts of which are perfectly naked. The supposed auditory apparatus is seated close to these organs; they are small vesicles, filled with liquid; the eyes having neither pupil nor cornea.

But it is in their reproduction that these evanescent beings present the most marvellous phenomena. At one period of the year the

Medusæ are charged with numbers of very minute eggs, of the most lively colours, which are suspended in large festoons from their floating bodies. In some cases these eggs develop themselves while still attached to their bodies, and are only detached at maturity. In some cases the larval forms produced bear no resemblance to the parent; they are elongated and vermiform, broad at their extremity, with vibrating cilia, scarcely perceptible, by which they execute the most lively motions. At the end of a certain time they are transformed into polyps, and furnished with eight tentacula. This preparatory sort of animal seems to possess the faculty of reproduction by means of certain buds or tubercles which develop themselves on the surface of the body, so that a single zooid form originates a numerous colony. The *Hydra tuba* is subjected to a transformation still more remarkable; its structure becomes complex, its body articulate, and it seems to be composed of a dozen discs piled one upon the other, like the jars of a voltaic pile; the upper disc is convex, and is separated from the colony after a convulsive effort; it becomes free, and an excessively small, star-like Medusa is the result; every disc, that is, every zooid form, is isolated one after the other in the same manner.

Thus some of these forms propagate their kind according to the usual laws, like producing like; but others bring forth young which have no resemblance to the parent at all; others are produced by budding, or fission, from individuals like themselves. These can also acquire sexual distinctions; but before this change takes place, the creature, which was simple, is transformed into a composite animal, and it is from its disaggregation that individuals having sexual organs are produced, the process being that which has been called *alternate* generation. It goes on in a perfectly regular manner, although it is a fact that the young never resemble their mothers, but their grandmothers.

This great class of the Hydrozoa is divided, by Professor Greene, into seven orders:—*Hydridæ*, where the polyps are locomotive and consisting of such forms as *Hydra viridis*, Fig. 4. *Corynidæ*, where the forms are attached and the ectodermic layer is generally firm; *Tubularia indivisa* is a well-known species. *Sertulariadæ*, where the animal is plant-like and much branched, and where the ectodermic layer forms cups in which the polyps dwell; as an example, *Sertularia cupressina* may be mentioned. *Calycophoridæ*, consisting of free oceanic forms with nectocalyces, see *Praya diphyes*, Fig. 42. *Physophoridæ*, also with free forms, but they are provided with a float or pneumatophore, in addition to nectocalyces (see PLATE III., p. 134,

Figs. 43, 46, 49, 50, 51. *Medusidæ*, where there is but a single polyp, and it is free and oceanic (Figs. 52, 53). And lastly, *Lucernaridæ*, which are easily distinguished from the previous order by their umbrella (see Figs. 54, 55, 56, 57, 58).

HYDRIDÆ.

The order *Hydridæ* comprehends but the single genus *Hydra*, of which many species are known, whose habits and metamorphoses it will be our object to particularise. The best known of these so-called species are *H. vulgaris*, *H. viridis*, *H. fusca*, and *H. rubra;* these differ for the most part from each other in size, colour, the form of the body, or in the relative proportions of the polypite and tentacles.

In this order the polyps are attached by a base which can be detached during locomotion. The integument does not secrete any horny or calcareous covering, but is easily resolved into two portions—an outer called the ectodermic layer, and an inner called the enodermic layer.

Hydra vulgaris (Fig. 40) inhabits stagnant ponds and slowly-running waters. It is of an orange-brown or red colour, the intensity of the colour depending on the nature of its food, becoming almost blood-red when fed on the small crimson worms and larva to be found in such places. M. Laurent even succeeded in colouring them blue, red, and white, by means of indigo, carmine, and chalk, without any real penetration of the tissue, the buds from them acquiring the same colour as the parent, while the colour of the ovum retains its natural tint, even when the mother Hydra has been fed with coloured substances during the progress of this mode of reproduction. The tentacula, usually seven or eight in number, never exceed the length of the body, tapering insensibly to a point.

Hydra viridis, another fresh-water polyp, being more immediately within the sphere of our observation, naturally presents itself to our notice. It is common in ponds and still waters. It was noticed by Pallas, who was of opinion that its young were produced from every part of its body. De Blainville, on the contrary, was of opinion that the young were always produced from the same place; namely, at the junction of that part which is hollow and that which is not. Van der Höven, late Professor of Natural History at Leyden, agrees with Pallas, and Dr. Johnston's opinion is the same. The green Hydra is common all over Europe, inhabiting brooks filled with herbage—attaching itself particularly to the duckweed of

stagnant ponds, and more especially to the under surface of the leaf. The animal is composed of a small greenish tubular sac, closed at one of its extremities, open at the other, and bearing round this opening from six to ten tentacles, very slender, sometimes not exceeding a line in breadth. The tubulous sac is the

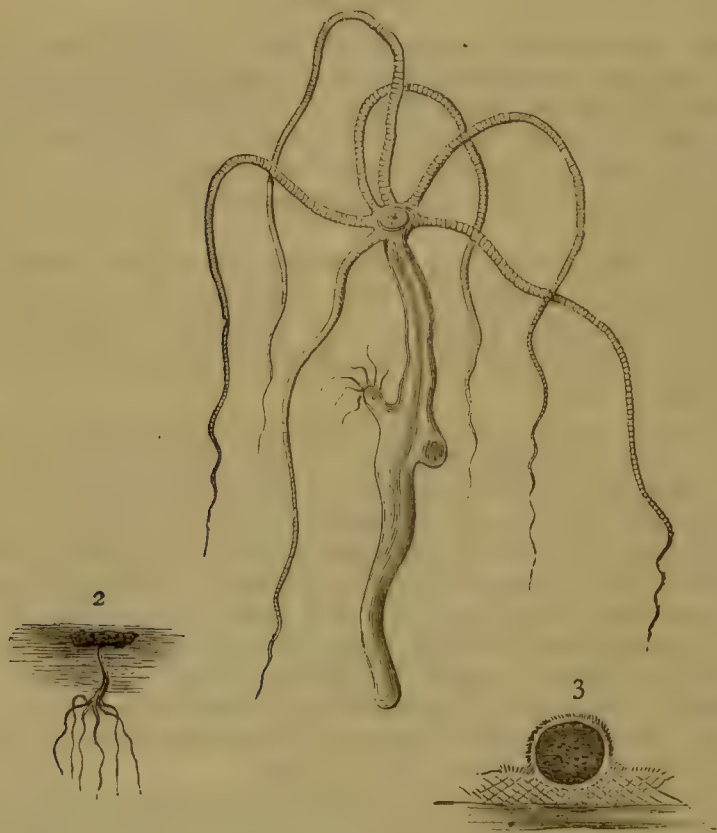


Fig. 40.—Hydra vulgaris. 1. Hydra with ovum and young, unhatched. 2 Hydra of natural size attached to a piece of floating wood. 3. Egg ready to burst its covering.

body of the animal (Fig. 41), the opening is at once its mouth and the entrance to the digestive canal; the appendages, the tentacula or arms.

The Hydræ have no lungs, no liver, no intestines, no nervous system, no heart. They have no organ of the senses, except those which may exist in their mouth and skin. The arms or tentacles are

hollow internally, and communicate with the stomach. They are provided with vibratile cilia, and are furnished with a great number of papillæ disposed spirally, and containing in their interior a number of capsules provided each with thread cells. These threads, which are of extreme tenacity, are thrown out when the animal is irritated

Fig. 41.—Hydra viridis (Trembley). 1. Hydra magnified, bearing an embryo ready to detach itself. 2. Animal, natural size.

by contact with any strange body. We may see these filaments wrapping themselves round their prey, sometimes even penetrating its substance, and effectually subduing the enemy. The green Hydra has thus a very simple organisation. Nevertheless, it would be a mistake to say the animal was imperfect, for it possesses everything necessary for its nourishment and for the propagation of its species.

There are learned men who have composed hundreds of volumes, who have published whole libraries—naturalists and physicists who have written more than Voltaire ever penned, but whose names are almost forgotten. On the other hand, there are some who have left only two or three monographs, and yet their names will live for ever. Of this number is A. Trembley. This writer published in 1744 a "Memoir on the Fresh-water Polyp." In this little work he recorded his observations on some of these animals of the smallest dimensions. He limited himself even to two sets of experiments; he turned the fresh-water polyp outside in, and he multiplied it by cutting it up. These experiments upon this little creature, which few persons had seen, have sufficed to secure immortality to his name. Trembley was tutor to the two sons of Count de Bentinck. He made his observations at the country-house of the Dutch nobleman, and he had, as he assures us, "frequent occasion to satisfy himself, in the case of his two pupils, that we can even in infancy taste the pleasures derivable from the studies of Nature!" Let us earnestly hope that this thought, uttered by a celebrated naturalist, who spoke only what he knew himself, may remain engraved on the minds of our younger readers.

Trembley established by his observations, a thousand times repeated, that *Hydra viridis* can be turned outside in as completely as a glove may be, without injury to the animal, which a day or two after this evolution resumes its ordinary functions. Such is the vitality of these little beings, that what was once the outer surface soon fulfils all the functions of a stomach, digesting its food, while the intestinal tube, expanding its exterior, performs all the functions of an outer surface, it absorbs and respires. But we shall leave Trembley to relate his very remarkable experiments.

"I attempted," he says, "for the first time to turn these polyps inside out in the month of July, 1741, but unsuccessfully. I was more successful the following year, having found an expedient which was of easy execution. I began by giving a worm to the polyp, and put it, when the stomach was well filled, into a little water which filled the hollow of my left hand. I pressed it afterwards with a gentle pinch towards the posterior extremities. In this manner I pressed the worm which was in the stomach against the mouth of the polyp, forcing it to open—continuing the pinching pressure until the worm was partly pressed out of the mouth. When the polyp was in this state I conducted it gently out of the water, without damaging it, and placed it upon the edge of my hand, which was simply moistened in order that the polyp should not stick to it. I forced it to

contract itself more and more, and, in doing so, assisted in enlarging the mouth and stomach. I now took in my right hand a thick and pointless boar's bristle, which I held as a lancet is held in bleeding. I approached its thicker end to the posterior extremity of the polyp, which I pressed until it entered the stomach, which it does the more easily since it is empty at this place and much enlarged. I continued to advance the bristle, and, in proportion as it advanced, the polyp became more and more inverted. When it came to the worm, by which the mouth is kept open on one side, and the posterior part of the polyp is passed through the mouth, the creature is thus turned completely inside out; the exterior superficies of the polyp has become the interior."

The poor animal would be justified in feeling some surprise at its new situation—disagreeably surprised, we may add, for it makes every imaginable effort to recover its natural position, and it always succeeds in the end: the glove is restored to its proper form. "I have seen polyps," says Trembley, "which have recovered their natural exterior in less than an hour." But this would not have served the purpose of our experimenter. He wished to know if the polyps thus turned outside in could live in this state; he had consequently to prevent it from righting itself, for which purpose a needle was run through the body near the mouth—in other words, he impaled the creature by the neck.

"It is nothing for a polyp only to be spitted," says Trembley. It is in fact a very small thing, as we shall see, for thus reversed and spitted they live and multiply as if nothing had happened.

"I have seen a polyp," says this ingenious experimenter, "turned inside out, which has eaten a small worm two days after the operation. I have fed one in that state for more than two years, and it has multiplied in that condition.

"Having experimented successfully myself, I was desirous of having the testimony of others capable of forming opinions on the subject. M. Allamand was persuaded to put his hand to the work, which he did with the same success I had met with. He has done more, having succeeded in permanently turning specimens which had been previously turned, and which continued to live in their re-inverted statè; he has seen them eat soon after both operations; finally, he has turned one for the third time, which lived some days, but perished without having eaten anything, although it did not appear that its death was the result of the operation."

We have said that the *Hydra viridis* has neither brain, nervous

system, heart, muscular rings, lungs, nor liver; the organs of the senses—namely, those of sight, hearing, and of smell—have also been denied them. Nevertheless, they act as if they possessed all these senses. O Nature! how hidden are thy secrets, and how the pride of man is humbled by the mysteries which surround thee—by the spectacles which strike his eye, and which he attempts in vain to explain!

Trembley states that the fresh-water polyps, having no muscular system, can neither extend nor contract themselves, nor can they progress. If touched, or if the water in which they are immersed is suddenly agitated, they are certainly observed to contract more or less forcibly, and even to inflect themselves in all directions; and by this power of extension, of contraction, and inflection, they contrive to move from place to place; but these movements are singularly slow, the utmost space they have been observed to traverse being about eight inches in the twenty-four hours.

Painfully conscious of his powers of progression, however, he has found means of remedying it, and the freshwater snail is his steed; he creeps upon the shell of a Planorbis, or a Limneus, and by means of this improvised mount he will make more way in a few minutes than he would in a whole day by his own unassisted efforts.

Hydra viridis, although destitute of organs of sight, is nevertheless sensible of light; if the vase containing them is placed partly in shade and partly in the sun, they direct themselves immediately towards the light; they appreciate sounds; they attach themselves to aquatic plants and other floating bodies. Without eyes, without brain, and without nerves, these animals lie in wait for their prey, recognise, seize, and devour it. They make no blunder, and only attack where they are pretty sure of success. They know how to flee from danger; they evade obstacles, and fight with or fly before their enemies. There are, then, some powers of reflection, deliberation, and premeditated action in these insignificant creatures; their history, in short, is calculated to fill the mind with astonishment.

Trembley insists much upon the address which the Hydra employs to secure its prey: by the aid of its long arms, small animals, which serve to nourish it, are seized, for it is carnivorous, and even passably voracious. Worms, small insects, and larva of dipterous insects are its habitual prey. When a worm or water flea in passing its tentacles happens to touch them, the polyp, taking the hint, seizes upon the wanderer, twining its flexible arms round it, and, directing it rapidly

towards its mouth, swallows it. Trembley amused himself by feeding the Hydra, while he observed the manner in which it devoured its prey.

"When its arms were extended, I have put into the water a woodlouse or a small worm. As soon as the woodlouse feels itself a prisoner it struggles violently, swimming about, and drawing the arm which holds it from side to side; but, however delicate it may appear, the arm of the polyp is capable of considerable resistance; it is now gradually drawn in, and other arms come to its assistance, while the polyp itself approaches its prey; presently the woodlouse finds itself engaged with all the arms, which, by curving and contracting, gradually but inevitably approach the mouth, in which it is soon engulfed."

Frédol also notices a singular fact. "The small worms, even when swallowed by the polyp," he says, "frequently try to escape; but the ravisher retains them by plunging one of its arms into the digestive cavity! What an admirable contrivance, by which the worms are digested while the arm is respected!"

The food of the fresh-water Hydra influences the colour of their bodies in consequence of the thinness and transparency of their tissues; so that the reddish matter of the woodlouse renders them red, while other food renders them black or green, according to its prevailing cololur.

The multiplication of these creatures takes place in three different ways:—

1. By eggs.
2. By buds, after the manner of vegetables.
3. By separation, in which an individual may be cut into two or many segments, each reproducing an individual.

We shall only say a few words on the first mode of reproduction. At certain seasons of the year ova are found to develop themselves in the substance of the lower part of the Hydra's body. These subsequently separate from the body, and appear to be capable of independent movements; but whether these be caused by cilia or not is not quite determined. After a time the sac of the ovum becomes ruptured, and the young Hydra bursts its way out.

Trembley has studied with great care the mode of reproduction by budding—a process which seems to prevail in the summer months. The buds which are to form the young polyp appear on the surface of the body as little spherical excrescences terminating in a point. A few steps further towards maturity, and they assume a conical, and finally a cylindrical form. The arms now begin to push out at the

anterior extremity of the young animal; the posterior extremity by which it is attached to the mother contracting by degrees, until it appears only to touch her at one point. Finally, the separation is effected, the parent and the young acting in concert to produce the entrance of this interesting young polyp into the world. Each of them take with their head and arms a strong point of support upon some neighbouring body; and a small effort suffices to procure the separation; sometimes the parent charges herself with the effort, sometimes the young, and often both.

When the young polyp is separated from the parent, it swims about, and executes all the movements peculiar to adult animals. The entrance into life and maturity takes place with these beings at one and the same moment. Infancy and youth are suppressed in this little world.

In the course of his experiments Trembley found the following remarkable fact.

Upon a young polyp still attached to its parent he observed a new polyp or polypule, and upon this unborn creature was another individual. Thus, three generations were appended to the parent, who carried at once her child, her grandchild, and great-grandchild.

"In observing the young polyps still attached to their parent," says Trembley, "I have seen one which had itself a little one which was just issuing from its body; that is to say, it was a mother while yet attached to its own parent. I had in a short time many young polyps attached to their parents which had already had three or four little ones, of which some were even perfectly formed. They fished for woodlice like others, and they ate them. Nor is this all. I have seen a mother-polyp which had carried its *third generation*. From the little one which he had produced issued another little one, and from this a third."

Charles Bennet, a naturalist of Geneva, says, wittily, that a polyp thus charged with all its descendants constitutes a living genealogical tree.

We have just spoken of turning polyps inside out! If one of these creatures is thus operated upon while it bears its young on the surface of its body, such of them as are sufficiently advanced continue to increase; although they find themselves in this sudden manner imprisoned in an internal cavity, and they re-issue subsequently by the mouth. Those less advanced at the moment of reversal issue by little and little from the maternal sac, and complete their career of development on the newly-made exterior.

The third and most extraordinary mode of reproduction in the polyps has been discovered by Trembley in the case of the green Hydra. So surprised was this naturalist at the strange anomalies which surround these creatures, that he began to have doubts, and gravely to ask the question, is this polyp an animal? or, is it a plant?

In order to escape from this state of indecision, it occurred to him to cut a Hydra into pieces. Concluding that plants alone could reproduce themselves by slips, he waited the result of the experiment for the conclusion he sought. On the 25th of November, 1740, he cut a polyp into sections. "I put," he tells us, "the two parts into a flat glass, which contained water four or five lines in depth, and in such a manner that each portion of the polyp could be easily observed through a strong magnifying glass. It will suffice to say that I had cut the polyp transversely, and a little nearer to the anterior. On the morning of the day after having cut the polyp, it seemed to me that on the edges of the second part, which had neither head nor arms, three small points were issuing from these edges. This surprised me extremely, and I waited with impatience for the moment when I could clearly ascertain what they were. Next day they were sufficiently developed to leave no doubt on my mind that they were true arms. The following day two new arms made their appearance, and, some days after, a third appeared, and I could now trace no difference between the first and second half of the polyp which I had cut."

This is assuredly one of the most startling facts belonging to natural history. Divide a fresh-water polyp into five or six parts, and at the end of a few days all the separate parts will be organised, developed, and form so many new beings, resembling the primitive individual. Let us add, that the polyp which should thus have lost five-sixths of its body, the mutilated father of all this generation, remains complete in itself; in the interval, it has recuperated itself and recovered all its primitive substance.

After this, if a *Hydra vulgaris* wishes to procure for itself the blessings of a family, it has only one thing to do: cut off an arm; if it desire two descendants, let it cut the arm in two parts; if three, let it divide it into three; and so on *ad infinitum*. "Divide one of the animals," says Trembley, "and each section will soon form a new individual in all respects like the creature divided." "A whole host of polyps hewn into pieces," says Frédol, "will be far from being annihilated." "On the contrary," we may say, in our turn, "its youth will be renewed, and multiplied in proportion to the number of

pieces into which it has been divided." "The same polyp," says Trembley, "may be successively inverted, cut in sections, and turned back again, without being seriously injured."

If a green Hydra is cut into two pieces, and the stomach is cut off in the operation, the voracious creature will, nevertheless, continue to eat the prey which presents itself. It gorges itself with the food, without troubling itself with the loss which it has sustained; but the food no longer nourishes it, for it merely enters by one opening, passes through the intestinal canal, and escapes by the other. It realises Harleville's pleasantry of M. de Crac's horse, in the piece of that name, which eats unceasingly, but never gets any fatter.

All these instances of mutilation, resulting in an increase of life, are very strange. The naturalists to whom they were first revealed could scarcely believe their own eyes. Réaumur, who repeated many of Trembley's experiments, writes as follows: "I confess that when I saw for the first time two polyps forming by little and little from that which I had cut in two, I could scarcely believe my eyes; and it is a fact that, after hundreds of experiments, I never could quite reconcile myself to the sight."

In short, we know nothing analogous to it in the animal kingdom. About the same period Charles Bennet writes: "We can only judge of things by comparison, and have taken our ideas of animal life from the larger animals; and an animal which we cut and turn inside out, which we cut again, and it still bears itself well, gives one a singular shock. How many facts are ignored, which will come one day to derange our ideas of subjects which we think we understand! At present we just know enough to be aware that we should be surprised at nothing."

Notwithstanding the philosophic serenity which Bennet recommends, the fact of new individuals resulting from dividing these fresh-water polyps was always a subject of profound astonishment, and of never-ending meditation.

Corynidæ.

We have already said that recent researches have led to a separation of this class of animals from the Sertularidæ, and to their being formed into an order by themselves. Of these creatures we formerly only knew one of the forms, namely, the polyp form; or, rather, the first stage of it. During their earliest days they possess a polyp, furnished with tentacles, and a bell-shaped body. During their medusoid

age, they present a central stomach, with four canals in the form of a cross, and four to eight tentacles with cirri. The *Corynidæ* comprehends many genera; among others the genera *Coryne*, *Hydractinia*, *Tubularia*, and *Cordylophora*, in studying which Van Beneden of Louvain discovered most interesting facts connected with the subject of alternate generation.

The Hydrozoa forming the Corynidæ have the power of secreting a hollow tube of a horny nature, in which the fleshy body can move up and down, expanding its tentacles over the top. Others of them give forth buds, each of which takes the form of a polyp, and these, being permanent, give it a shrub-like or branched appearance; it is now a compound polyp. The tube is branched, but the orifices from which the polyps expand never dilate into cups or cells. The Tubularia are plant-like and horny, rooted by fibres, tubular, and filled with a semi-fluid organic pulp; polyps naked and fleshy, protruding from the extremity of every branchlet of the tube, and armed with one or two circles of smooth filiform tentacles; the reproductive bodies germinating from the base of the tentacles; embryo medusiform. "Some modern authors," says Frédol, "assure us that the tree-like form of these polyps is a degraded and transitory form of the Medusæ. The Medusa originates the polyp, the polyp becomes a Medusa." *Eudendrium rameum* so perfectly resembles an old tree in miniature, deprived of its leaves, that it is difficult to believe it is not of a vegetable origin; it is like a vigorous tree in miniature, in full flower, rising from the summit of a brown-spotted stem, with many branches and tufted shoots, terminating in so many hydra-like polyps of a beautiful yellow or brilliant red. *E. ramosum*, of a brownish colour and horny substance, rising six inches, is rooted by tortuous, wrinkled fibres, with flexible, smooth, and thread-like shoots, branching into a doubly pinnate form. In *Tubularia indivisa* the tubes are clustering; its numerous stems are horny, yellow, and from six to twelve inches in height, about a line in diameter, and marked with unequal knots from space to space, like the stalk of the oat-straw with the joints cut off. Their lower extremity is tortuous, attaching themselves readily to shells and stones in deep water, flourishing in deep muddy bottoms, and upright as a flower, fixed by the tapering root-like terminations of their horny tube: a flowering animal, having, however, neither flower nor branch. At the summit of each stem a double scarlet corolla is developed of from five to thirty-five petals, in rows, the external one spreading, those in the interior rising in a tuft; a little below, the ovarium appears, drooping, when ripe, like a bunch of orange-coloured grapes. After a time the petals

of the corolla fade, fall, and die, and a bud replaces them, which produces a new polyp; and so on. This succession determines the length of the stem. Each apparent flower throws out a small tube, which terminates it, and each addition adds one joint more to the axis, which it increases in length.

SERTULARIADÆ.

All the *Hydrozoa*, with the exception of *Hydra* and a few other genera, are marine productions, varying in size from a few lines to upwards of a foot in height. The members of this order are found attaching themselves to rocks, shells, seaweeds, and corallines, and to various species of crustacea. Many of them attach themselves indiscriminately to the nearest object, but others show a preference for some special substance. *Thuiaria thuia* attaches itself to old bivalves; *Thoa halecinia* prefers the larger univalves; *Antennularia antennina* attaches itself to coarse sand or rocks; *Laomedea geniculata* delights in the broad frond of the tangle; *Plumularia catherina* attaches itself in deep water to old shells, corallines, and ascidians, growing in a manner calculated to puzzle the naturalist, as it did Crabbe, the poet, who writes of it:—

> "Involved in sea-wrack, here you find a race
> Which science, doubting, knows not where to place;
> On shell or stone is dropp'd the embryo seed,
> And quickly vegetates a vital breed."

Sertularia pumila, on the other hand, loves the commoner and coarser wrack. "The choice," says Dr. Johnston, "may in part be dependent on their habits, for such as are destined to live in shallow water, or on a shore exposed by the reflux of every tide, are, in general, vegetable parasites; while the species which spring up in deep seas must select between rocks, corallines, or shells." There seems to be a selection even as to the position on the rocks. According to Lamouroux, some polyps always occupy the southern slopes, and never that towards the east, west, or north; others, on the contrary, grow only on these exposures, and never on the south, altering their position, however, according to the latitude, and its relation to the Equator.

The *Sertularidæ* have a horny stem, sometimes simple, sometimes so branching that they might readily enough be mistaken for small plants, their branches being flexible, semi-transparent, and yellow. Their name is derived from *Sertum*, a bouquet. Each Sertularia has

seven, eight, twelve, or twenty small panicles, each containing as many as 500 polyps; thus forming, sometimes, an association of 10,000 polyps. "Each plume," says Mr. Lister, in reference to a specimen of *Plumularia cristata*, "might comprise from 400 to 500 polyps;" "and a specimen of no unusual size now before me," says Dr. Johnston, "with certainly not fewer cells on each than the larger number mentioned, thus gives 6,000 as the tenantry of a single polypidom, and this on a small species." On *Sertularia argentea* it is asserted, polyps are found on which there exist not less than 80,000 to 100,000.

Each colony is composed of a right axis, on the whole length of which the curved branches are implanted, these being longest in the middle. Along each of these branches the cells, each containing a polyp, are grouped alternately. The head of the animal is conical, the mouth being at the top, surrounded by twenty to twenty-four tentacles.

Certain polyps belonging to the same colony, which seem destined to perpetuate the race, have not the same regular form. Destitute of mouth and tentacles, they occupy special cells, which are larger than the others. The entire colony is composed exclusively of individuals, male or female. "We have traced *Sertularia cupressina* through every stage of its development," say Messrs. Paul Gervais and Van Beneden. "At the end of several days the embryos are covered with very short vibratile cilia; their movement is excessively slow; then, from the spheroid form which they take at first, they get elongated, and take a cylindrical form, all the body inclining slightly sometimes to the right, sometimes to the left. The vibratile cilia fading afterwards, the embryo attaches itself to some solid body, a tubercle is formed, and the base extends itself as a disc. At the same time that the first rudiments of the polyp appear, the disc-like tubercle throws out on its flanks a sort of bud, and a second polyp soon shows itself; its surface is hardened; the polyp appears in its turn, and the same process of generation is repeated; a colony of *Sertulariadæ* is thus established at the summit of a discoid projection. At the end of fifteen days the colony, which has been forming under our eyes, consists of two polyps and a bud, which already indicates a third polyp. The sea-cypress, as this species is called, is robust, with longish branches decidedly fan-shaped, the pinnæ being closer and nearly parallel to each other. The cells form two rows, nearly opposite, smooth and pellucid. The branches in some specimens are gracefully arched, bending as it were under the load of pregnant ovaries which they carry, arranged in close-set rows along the upper

side of the pinnæ. They are found in deep water all around our coasts. The cells, which are the abode of the polyps are not always alike in their distribution. Sometimes they are ranged on two sides, sometimes on one only. Sometimes they are grouped like the small tubes of an organ, at other times they assume a spiral form round the stem, or they form here and there horizontal rings round it."

The Campanularinæ differ considerably from the above, and form a second family of this order, the ends of their branches, whence the polyps issue, being enlarged into a bell-like shape, whence their name. *Laomedea dichotoma* is at once the most delicate and most elegant of the species. It presents a brownish stem, thin as a thread of silk, but strong and elastic. The polyps are numerous: upon a tree eight or nine inches high there may be as many hundreds. *Campanularia volubilis* is a minute microscopical species, living parasitically on corallines, seaweed, and shelled animals. The stem is a fine corneous tube, which creeps and twists itself upon its support, throwing out at alternate intervals a long slender stalk, twisted throughout or only partially, which supports a bell-shaped cup of perfect transparency, and prettily serrated round the brim. Dr. Johnston found the antennæ of a crab so profusely infested with them as to resemble hairy brushes. It is furnished, according to Hassall, with a delicate joint or hinge at the base of each little cup—a contrivance designed, it is imagined, to enable the frail zoophyte the better to elude the rude contact of the element in which it lives, by allowing it to bend to a force which it cannot resist.

The Campanularinæ increase by budding, the buds being found in much the same manner as in the Hydra. They form at first but a simple excrescence, which, in due time, takes the form of the branch from which it proceeds. These buds have their origin at certain distances, and form a new series of polyps.

Calycophoridæ.

This order consists of free oceanic forms, provided with swimming bells or nectocalyces.

In the family of Diphydæ but two natatory vesicles are connected with the stem, as in *Praya diphyes*, Fig. 42. This species is widely diffused in the sea which bathes the Nicean coast, but it is very difficult to procure perfect specimens of it. M. Vogt found fragments more than three feet long which swam on the surface, and was in its state of contraction not more than a finger's length. This species

has been met with at Porta della Praya and at San Yago, one of the Cape de Verde islands.

The colony of *Praya diphyes* presents two great locomotive bell-shaped masses, between which the common stem is suspended. This cylindrical stem, which is thin and transparent, carries on it at

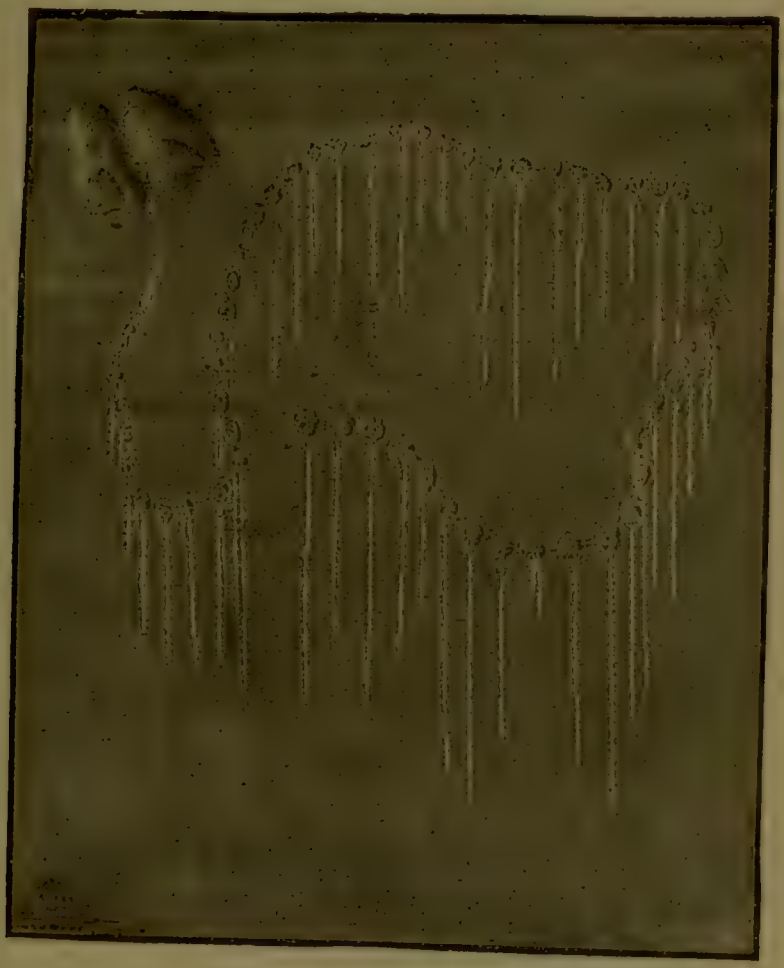


Fig. 42.—Praya diphyes (Blainville).

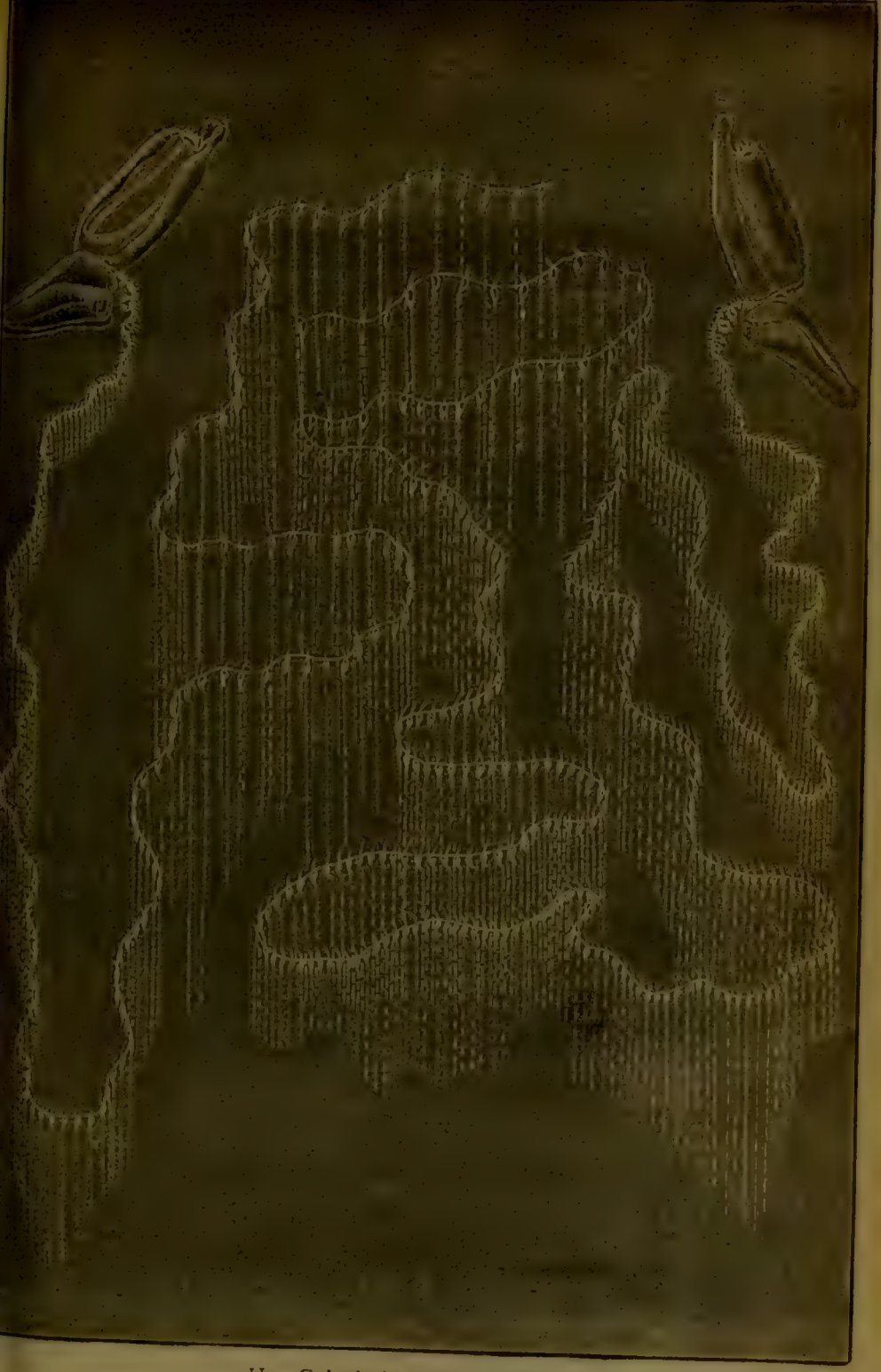
intervals certain groups very exactly circumscribed and individualised. Each of these groups consists of a nursing polyp, having its fishing-line with a special floating air bladder, a reproductive bud male or female, and a protecting bract enveloping the whole.

Another species having a great resemblance to the *Praya* is *Galeolaria aurantiaca*, or orange Galeolaria, which is represented on the opposite plate (PLATE II.), borrowed from the fine "Memoir of the Inferior Animals of the Mediterranean," by Carl Vogt. Here we find only two great floating bladders placed at each extremity of a common stem, and serving the purpose of a locomotive apparatus to the whole colony. This stem carries in like manner polyps placed at regular intervals forming isolated groups, provided each with its protecting bracts. But there is no special swimming apparatus for each of these groups. Moreover, each colony is either male or female.

PHYSOPHORIDÆ.

These inhabitants of the deep are graceful in form, and are distinguished by their delicate tissues and brilliant colours. Essentially swimmers, supported by one or many vessels filled with air—having also, as in the previous Order, mostly true-swimming-bladders, more or less numerous, and of variable form—they float upon the waves, remaining on the surface whatever may be the state of the sea. They are natural skiffs, and almost incapable of immersion. The Physophoridæ form several families, the principal of which are the *Apolemianæ* (Fig. 43), the *Stephanominæ* (PLATE III., p. 134), *Physophorinæ* (Fig. 46), *Physalinæ* (Fig. 49), and *Velellinæ* (Figs. 50, 51).

The *Apoleminæ* contains but a single genus, *Apolemia*. The pretty *A. contorta* of Milne-Edwards (Fig. 43), inhabits the Mediterranean, and particularly the coast of Nice. This elegant species is often met with in the Gulf of Villafranca, near Nice, and has been figured and described by Milne-Edwards, Charles Vogt, and also by M. de Quatrefages, who asks the reader "to figure to himself an axis of flexible crystals, sometimes more than a mètre (forty inches) in length, all round which are attached, by means of long peduncles or footstalks equally transparent, some hundreds of bodies, sometimes elongated, sometimes flat, and formed like the bud of a flower. If we add to this garland of pearls of a vivid red colour an infinity of fine filaments, varying in thickness, and giving life and motion to all these parts, we have even now only a very slight and imperfect idea of this marvellous organism." The swimming-bells in *Apolemia contorta* consist of a mass having the form of an elongated egg cut in the middle. They are arranged in a vertical series of twelves, and the axis which supports them is terminated by the aërial vesicle or float. This axis is always arranged in a spiral form, even in its greatest expansion,



II.—Galeolaria aurantiaca (Vogt).

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it is of a fine rose tint, and flattened into the form of a ribbon ; it is marked in all its length with asperities or hollow dimples, in which the filamental appendages originate.

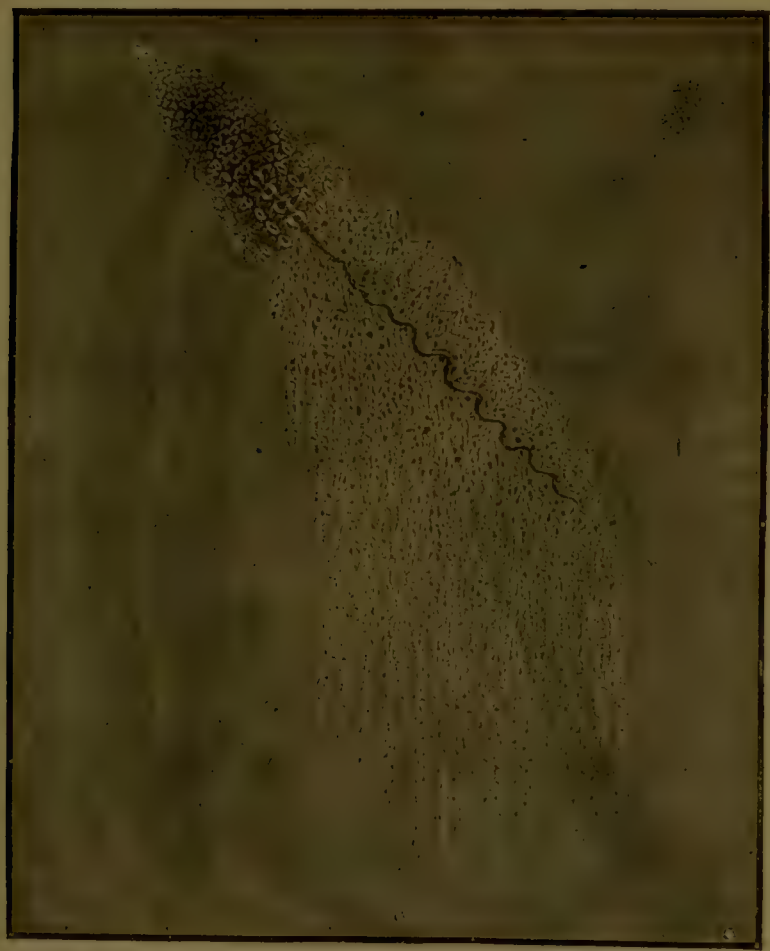


Fig. 43 — Apolemia contorta, one-third natural size (Milne-Edwards)

The nursing polyps have been called *proboscidiferous* organs by M. Milne-Edwards, who has studied them carefully. They are rendered conspicuous at a glance by the bright-red colour of their digestive cavity and their extreme dilatability. At the base of their stems the very delicate filaments called fishing-lines are attached

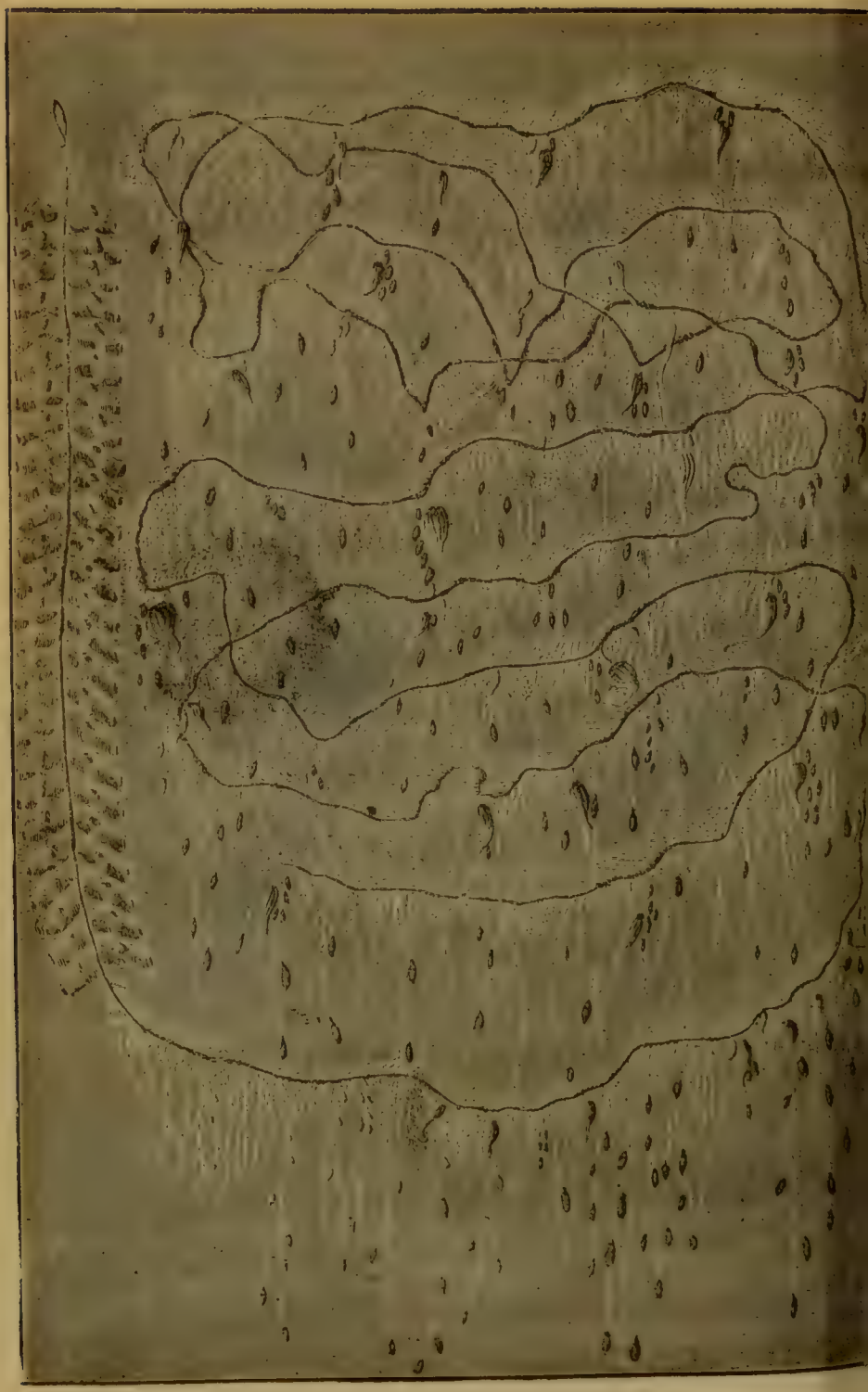
which are furnished with a multitude of stinging tendrils of a reddish colour. These tendrils slightly resemble those met with in Agalma, and the sabre-like weapons are not wanting.

Between the nursing polyps are placed in pairs the reproductive

Fig. 44.—Apolemia contorta, magnified 12 times.

Fig. 45.—Apolemia contorta, reproductive pair, magnified 12 times.

individuals, having the form of an elongated tube very dilatable, and closed at the free end. They have then, no mouth! Milne-Edwards calls these "vesicular appendages," and M. Kölliker calls them tentacles. The buds arranged at the base of each prolific individual vary; but, according to M. Vogt, they are always there in pairs—a male and female at the base of each stem. Figs. 44 and 45



III.—Agalma rubra, three-fifths natural size.

represent the colony we have endeavoured to describe, 44 being the nursing individual of *Apolemia contorta* magnified twelve times, 45 representing the reproductive pair under the same magnifying power.

The *Stephanominæ* contain several genera, among these the genus *Agalma;* and there is no animal form more graceful than *Agalma rubra*, which is reproduced in PLATE III., from Vogt's Memoir. This beautiful creature is common in the Mediterranean, on the coast near Nice, from November till the month of May. Towards the middle of December Vogt found nearly fifty individuals, in the space of an hour, opposite to the port of Nice, all following the same current—a prodigious quantity of Salpæ, Medusæ, and small pteropodean molluscs accompanying them.

"I know nothing more graceful," says Vogt, "than this Agalma, as it floats along near the surface of the waters, its long, transparent, garland-like lines extended, and their limits distinctly indicated by bundles of a brilliant vermilion red, while the rest of the body is concealed by its very transparency; the entire organism always swims in a slightly oblique position near the surface, but is capable of steering itself in any direction with great rapidity. I have had in my possession some of these garlands more than three feet in length, in which the series of swimming bladders measured more than four inches, so that in the great vase in which I kept them the column of swimming bladders touched the bottom, while the aërial vesicle floated on the surface. Immediately after its capture the columns contracted themselves to such a point that they were scarcely perceptible, but when left to repose in a spacious vase, all its shrunken appendages deployed themselves round the vase in the most graceful manner imaginable, the column of swimming-bladders remaining immovable in their vertical position, the float at the surface, while the different appendages soon began to play. The polyps, planted at intervals along the common trunk, of rose-colour, began to agitate themselves in all directions, taking a thousand odd forms; the reproductive individuals, like the tentacles, were contracting and twisting about like so many worms; the tentacles were stirred, the ovarian clusters began to dilate and contract, the spasmodic swimming-bladders agitated the waters with their umbrellas, like the Medusæ; but what most excited my curiosity, was the continuous action of the fishing-lines, which continued to unroll and contract in a most surprising manner, retiring altogether sometimes with the utmost precipitation. All who have witnessed these living colonies, withdraw themselves reluctantly from the strange spectacle, where each polyp seems to

play the part of the fisherman who throws his line, furnished with baited hooks, withdrawing it when he feels a nibble, and throwing again when he discovers his disappointment. These efforts continued in full vigour for two or three days, and I have succeeded sometimes in feeding them with the small crustaceans which swarm on our coasts."

Of the *personnel* of these colonies a few words will not be misplaced. The common axis of the *Agalma* is a hollow muscular tube, the length of which may be three feet, and its breadth an eighth or tenth of an inch; it is traversed by a double current of a granular fluid; at its summit is the aërial vesicle; beneath are the swimming-bladders. These are disposed along the trunk in a double series, attaining sometimes the number of sixty; their structure is analogous to the same organs in Physophora.

In examining the posterior portion of the trunk, traversing polyps are observed at intervals, whose base is surrounded by a cluster of reddish grains, each of which is armed with a *line*, and, with its surrounding filament, terminating in a tendril of a red vermilion colour, which is a perfect arsenal of offensive and defensive arms. There we find "*sabres*" of divers sizes, and poniards of various forms, the whole constituting a truly formidable stinging apparatus.

Those warlike engines, those arms of attack and defence with which man surrounds himself, Nature has freely bestowed on these little creatures with which the ocean swarms in some places. It might be said that, after having created these graceful creatures to ornament and decorate the depths of the ocean, the Creator was so pleased with his work that he furnished them with arms for their protection and defence against all attacks from without.

The family *Physophorinæ* includes several genera. Fig. 46 is a representation of *Physophora hydrostatica*, after M. Vogt's Memoir. We see that the animal is composed of a slender vertical axis, terminating in an aërial vesicle or float, carrying laterally certain vesicles, known as swimming-bladders, which terminate in a bundle of whitish slender threads.

The aërial vesicle is brilliant and silvery, punctured with red spots. The swimming-bladders are encased in transparent and somewhat cartilaginous capsules, which are continued into the common median trunk, the latter being rose-coloured, hollow, and very contractile; in short, it presents very delicate muscular fibres, which expand themselves on the external surface of each capsule, and is closed on all sides.

The swimming-bladders are of a glass-like transparency, and of a

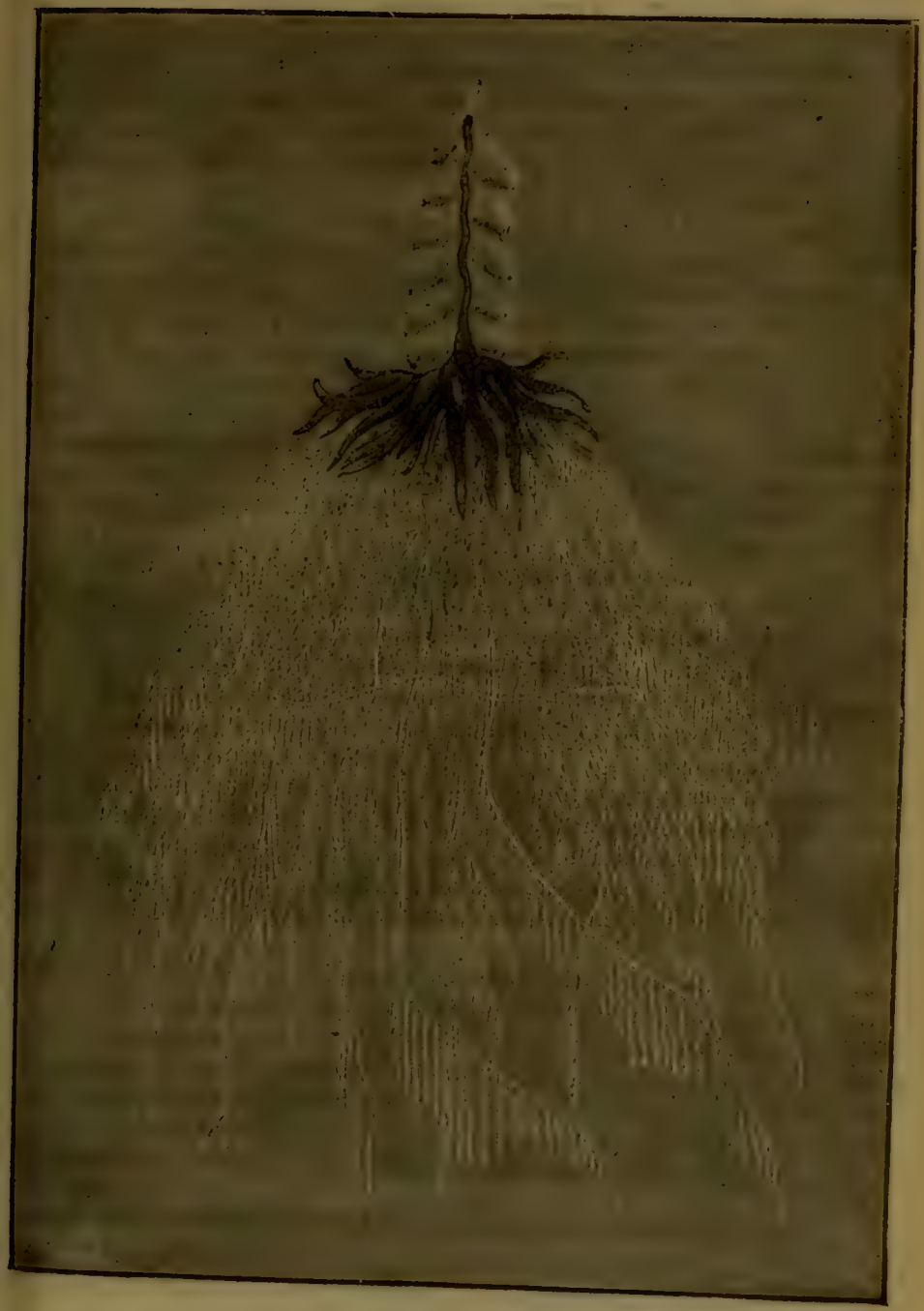


Fig. 46.—Physophora hydrostatica (Forskal).

firm, compact tissue. They are attached obliquely and alternately upon a common axis, presenting an exterior curvature, a round opening, furnished with a fine, muscular, and very contractile limb, and arranged like the iris of the eye. Their power of resistance is increased by certain horny hollow threads, which are in direct communication with the cavity of the vertical axis, and have their origin in a common circular canal.

"The animal," says Vogt, "is enabled to guide itself in any direction by means of the swimming apparatus or air-bags. These, on opening, are filled with water, which is again ejected in the contractile movement, for their movements may be compared to that of the umbrella of the Medusæ. It is the violent expulsion of this liquid which enables the animal to advance diagonally through the water, a kind of motion which is the consequence of its organisation; for where both rows of air-bags are working in the direction of the axis of the stem, the organism will incline to the side which works most, but always in such a manner that the aërial vesicle will be borne forward."

In its lower parts the stem expands, becomes flat, and winds itself in a spiral. It is hollow, and encloses a transparent viscous liquid, in which very small granules are observed, which appear to be the result of digestion. To this are attached three different sorts of appendages. We shall first address ourselves to the tentacles.

These form a crown or bundle of vermiform appendages, of a reddish colour, over an inch in length, and which are kept continually in motion: these are formed of a glass-like cartilaginous substance; they are conical tubes, closed on all parts except at the point where the tentacle is attached to the disc. Their cavity is filled with the granulous liquid already mentioned. On the under surface of the disc, and to the inside of these tentacles the polyps and fishing-lines are attached.

The anterior part of the polyp is formed of a glass-like substance, which changes its form in the most varied and surprising manner. It bears a roundish mouth at its summit. In its posterior part the polyp presents a straight hollow stem, of reddish colour; but near to this red stem we find a thick tuft of cylindrical appendages, from the middle of which spring the extensible and contractile filament which Vogt calls the *fishing-lines* (fil pêcheur), and of which he has given the following very strange account:—

"Each of these appendages consists of an assemblage of cylindrical tubes somewhat resembling and analogous to the filament of a Conferva. All these tubes are traversed by a continuous canal, which originates

in the internal cavity of the stem of the polyp. Each fragment of the line is capable of a prodigious extent of elongation and contraction; but where completely drawn back the pieces fold themselves up somewhat in the manner of a pocket foot-rule. It is to the combined effect of contraction and the unfolding of the pieces that these lines owe the marvellous changes of length which they present." In

Fig. 47.—P. hydrostatica, with a portion of the disc, three polyps, and reproductive clusters attached.

Fig. 47 are represented the polyps and fishing-lines of *P. hydrostatica*, with a portion of the disc and two pairs of reproductive clusters.

In this figure it will be observed that each fragment or joint has implanted, near the articulation, a secondary line, which bears the stinging organ. Each of these filaments consists of three parts—a straight stem, muscular, contractile, and hollow, the cavity of which communicates with that of the trunk which carries it; a middle part, a sort of tube containing, in a considerable internal cavity, a transparent liquid; finally, an inflated stinging organ, which terminates the apparatus. This last is egg-shaped, and consists internally of a hyaline substance of cartilaginous consistence, in the interior of which

we find a great cavity, which opens from within, near the base of the capsule; to the inside of this cavity a second muscular sac is atttached all round the opening of the capsule, in such a manner that the opening leads directly into the cavity of the sac. This cavity conceals in its interior a long filament usually rolled up in a spiral, as illustrated in Fig. 48, where the two urticating capsules of the stinging apparatus of *Physophora hydrostatica* are represented, one of them being a section, magnified by twelve diameters. This spirally rolled-up filament consists of a large quantity of very small, hard, sabre-shaped, corpuscular bodies, supported the one against the other, and having their points turned inwards. These objects Vogt terms "urticant sabres;" the extremity of the filament consists of curved corpuscles, larger, of a brownish yellow, very strong, and with a double point. M. Vogt had also opportunities of observing the action of these stinging capsules. He has seen them burst naturally, and he has also obtained artificially the same result. In the former case the filament issues from the opening left at the base of the capsule with a sort of explosion. "The use," he says, "of the fishing-lines becomes evident when we see a Physophora in repose in a vase large enough for its full development; then it takes a vertical position; the lines elongate themselves more and more, by unfolding one by one the secondary lines with stinging capsules, and the Physophora now resembles a flower posed upon a tuft of roots, with extremely long and delicate rootlets reaching to the bottom of the vase. But in the case of the Physophora the living roots are in continual motion. Each line is elongated, foreshortened, and contracted in a thousand ways. The least movement of the water causes the stinging capsules to be suddenly drawn up, the lines hauled in most rapidly being those near the crown of tentacles. This continuous play of the lines has no other object than to attract the prey destined to feed the polyp, and we cannot find any better comparison for them than the fishing-lines to which they have been compared. The moment that some small microscopical medusæ, larva, or crustacean, come within the sphere of those redoubted lines, it is at once surrounded, seized, and led with irresistible force towards the mouth of this polyp by a gentle and gradual contraction of the line; the stinging organs, complicated as we have seen them to be in the Physophora, thus serve the same purpose as the stinging organs disposed on the arms of the Hydra, or on the external surface of the tentacles and prolific polyps of the Velella.

Let us finally note among the *Physalinæ*—a family it will be recollected of *Physophoridæ*—a form which has attracted great

attention, and has been described under many names. Sailors call it the sea-bladder, from its resemblance to that organ; it is also known as the Portuguese man-of-war, from its fancied resemblance to a small ship as it floats along under its tiny sail. Naturalists after Eschscholtz call it *Physalia utriculus*, from the Greek word, φυσαλὶς,

Fig. 48.—Offensive apparatus of Physophora hydrostatica

a bubble, and *utriculus* from its stinging powers. It was long thought that the Physalia was an isolated individual. But, according to recent researches, it forms, like the species already described, an animal republic.

Let us imagine a great cylindrical bladder dilated in the middle, attenuated and rounded at its two extremities, of eleven or twelve

inches in length, and from one to three broad. Its appearance is glassy and transparent, its colour an imperfect purple, passing to a violet, then to an azure above. It is surmounted by a crest, limpid and pure as crystal, veined with purple and violet in decreasing tints. Under the vesicle float the fleshy filaments, waving and contorted into a spiral form, which sometimes descend perpendicularly like so many threads of celestial blue. Sailors believe that the crest which surmounts the vesicle performs the office of a sail, and that it tells the navigator "how the wind blows," as they say. This bladder-like form, with its aërial crest, is only a hydrostatic apparatus, whose office is to lighten the animal, and modify its specific gravity.

"This bladder," says Gosse, in his "Year by the Sea-side," "is filled with air, and therefore floats almost wholly on the surface. Along the upper side, nearly from end to end, runs a thin edge of membrane, which is capable of being erected at will to a considerable height, fully equal at times to the entire width of the bladder, when it represents an arched fore-and-aft sail, the bladder being the hull. From the bottom of the bladder, near the thickest extremity, where there is a denser portion of the membrane, depends a crowded mass of organs, most of which take the form of very slender, highly contractile, movable threads, which hang down into the deep to a depth of many feet, or occasionally of several yards.

"The colours of this curious creature are very vivid; the bladder, though in some parts transparent and colourless, and in some specimens almost entirely so, is in general painted with richest blue and purple, mingled with green and crimson to a smaller extent, these all being, not as sometimes described, iridescent or changeable, but positive colours independent of the incidence of light, and, for the most part, possessing great depth and fulness. The sail-like erectile membrane is transparent, tinted towards the edge with a lovely rose-pink hue, the colours arranged in a peculiar fringe-like manner. When examined anatomically, the bladder is found to be composed of two walls of membrane, which are lined with cilia, and have between them the nutritive fluid which supplies the place of the blood. Besides this, the double membrane is turned in or inverted like a stocking prepared for putting on; and thus there is a bladder within a bladder, both having double walls; the inner (*pneumatocyst*) much smaller than the outer (*pneumatophore*), and contracted at the point where it is turned into the almost imperceptible orifice. The inner sends up closed tubular folds into the crest,

which, being arrested by the membranous walls of the outer sac, give to the sail that appearance of vertical wrinkles which is so conspicuous."

When it is filled with air the body of the bladder is almost projected out of the water. In order to descend it is necessary to compress itself or dispel the air, in part, for the centre of gravity in the animal is displaced according as the air is in the vesicle or in the crest. When the last is distended it rises out of the water, and becomes nearly vertical; in short, it then becomes a sort of sail. The floating appendages beneath the body are of divers kinds. Some of these are reproductive individuals; some are nurse forms; some are tentacles; finally, there are organs designated under the name of *Sondes* by French naturalists; probes or suckers, we may call them, forming offensive and defensive arms truly formidable; for these elegant creatures are terrible antagonists. Du Tertre, the veracious historian of the Antilles, relates the following:—"This 'galley' (our Physalia), however agreeable to the sight, is most dangerous to the body, for I can assert that it is freighted with the worst merchandise which floats on the sea. I speak as a naturalist, and as having made experiments at my own personal cost. One day, when sailing at sea in a small boat, I perceived one of these little 'galleys,' and was curious to see the form of the animal; but I had scarcely seized it, when all its fibres seemed to clasp my hand, covering it as with birdlime, and scarcely had I felt it in all its freshness (for it is very cold to the touch) when it seemed as if I had plunged my arm up to the shoulder in a caldron of boiling water. This was accompanied with a pain so strange that it was only with a violent effort I could restrain myself from crying aloud."

Another voyager, Leblond, in his "Voyage aux Antilles," relates as follows:—"One day I was bathing with some friends in a bay in front of the house where I dwelt. While my friends fished for sardines for breakfast, I amused myself by diving, in the manner of the native Carribeans, under the wave about to break; having reached the other side of one great wave, I had gained the open sea, and was returning on the top of the next wave towards the shore. My rashness nearly cost me my life: a Physalia, many of which were stranded upon the beach, fixed itself upon my left shoulder at the moment the wave landed me on the beach. I promptly detached it, but many of its filaments remained glued to my skin, and the pain I immediately experienced was so intense that I nearly fainted. I seized an oil flask which was at hand, and swallowed one half, while I rubbed my arm with the other: this restored me to myself, and I

returned to the house, where two hours of repose relieved the pain, which disappeared altogether during the night."

Mr. Bennett, who accompanied the exploring expedition under Admiral Fitzroy, as naturalist, ventured to test the powers of the Physalia. "On one occasion," he says, "I tried the experiment of its stinging powers upon myself, intentionally. When I seized it by the bladder portion, it raised the long cables by muscular contraction of the bands situated at the base of the feelers, and, entwining the slender appendages about my hand and finger, inflicting severe and peculiarly pungent pain, it adhered most tenaciously at the same time, so as to be extremely difficult of removal. The stinging continued during the whole time that the minutest portion of the tentacula remained adherent to the skin. I soon found that the effects were not confined to the acute pungency inflicted, but produced a great degree of constitutional irritation: the pain extended upwards along the arm, increasing not only in extent but in severity, apparently acting along the course of the absorbents, and could only be compared to a severe rheumatic attack. The pulse was accelerated, and a feverish state of the whole system produced: the muscles of the chest, even, were affected; the same distressing pain being felt on taking a full respiration as obtains in a case of acute rheumatism. The secondary effects were very severe, continuing for nearly three-quarters of an hour; the duration being probably longer in consequence of the time and delay occasioned by removing the tentacula from the skin, to which they adhered, by the aid of the stinging capsules, with an annoying degree of tenacity. On the whole being removed, the pain began to abate; but during the day a peculiar numbness was felt, accompanied by an increased temperature in the limb on which the sting had been inflicted. For some hours afterwards the skin displayed white elevations, or weals, on the parts stung, similar to those resulting from the poison of the stinging nettle. The intensity of the pain depends in some degree upon the size and consequent power of the creature. After it has been removed from the water for some time, the stinging property, although still continuing to act, is found to have perceptibly diminished. I have observed, also, that this irritative power is retained for some weeks after the death of the animal in the vesicles of the cables, and even linen cloth which has been used for wiping off the adhering tentacles, when touched, still retained the pungency, although it had not the power of producing such violent constitutional irritation."

"The sea-bladder," says Father Feuillée, "occasions me, on touching it, a sudden and severe pain, accompanied with convulsions."

"During the first voyage of the *Princess Louise* round the world," to quote Frédol, "Meyen remarked a magnificent Physalia, which passed near the ship. A young sailor leaped naked into the sea, to seize the animal. Swimming towards it, he seized it; the creature surrounded the person of its assailant with its numerous thread-like filaments, which were nearly a yard in length; the young man, overwhelmed by a feeling of burning pain, cried out for assistance. He had scarcely strength to reach the vessel and get aboard again, before the pain and inflammation were so violent that brain fever declared itself, and great fears were entertained for his life."

The question has been much agitated, without being positively resolved, whether the Physalia are poisonous or not: if they can kill or make sick the man or animal which swallows them. Listen to the opinions of M. Ricord-Madiana, a physician of Guadaloupe, who made direct experiments with a view to settling the question. "Many inhabitants of the Antilles," he says, "say that the 'galleys; are poisonous, and that the negroes make use of them, after being dried and powdered, to poison both men and animals. The fishermen of the islands also believe that fish which have swallowed them become deleterious, and poison those that eat them, a prejudice which has been adopted by many travellers, and has even found its way into scientific books. We can state as the result of direct experiment, that though the 'galley,' will burn the ignorant hand which is touched by its tentacles, when dried in the sun and pulverised it becomes mere grains of dead matter, producing no effect whatever upon the animal economy."

"Let us report our own experiments," continues M. Ricord-Madiana.

"I. I had placed a 'galley' in the sun, in order to dry and pulverise it. A nest of ants were there, who devoured the whole of it. Now, many persons in the islands think that these insects will not touch venomous fishes.

"II. Another 'galley,' which I had left on the table in my laboratory, was attacked by a number of great flies, who deposited their eggs there; these were duly hatched, and the larva fed on the decomposed zoophyte.

"III. On the 12th of July, 1823, I saw on the sands in the bay between St. Mary and La Goyave, at Guadaloupe, many Physalia recently cast ashore. Having a dog with me, with the assistance of my servant, I made him swallow the freshest of them, with all its filiform tentacles, pushing it down his throat, while my servant held his mouth open; five minutes after, the dog exhibited symptoms of

great pain on the edges of its lips; it foamed at the mouth and rubbed it in the sand, or upon the grass, leaping about, passing its paws over its jaws, and exhibiting every symptom of excessive pain. I mounted my horse, and, in spite of its sufferings, the poor animal followed me as it was wont. After twenty minutes, when its sufferings were over, I had a piece of bread, which I gave it, and it ate it with appetite, swallowing it without any difficulty; it only seemed to feel the pain on the edges of its mouth: it was well enough all day, and had evacuations which gave no indication that the Physalia had any influence over the digestive organs. Next day and the day following it was as well as usual, exhibiting no signs of inflammation either in the mouth or throat.

"IV. On the 20th of the same month I took two 'galleys' on the sea-shore and cut them in pieces; then, with a spoon, I had them forced down the throat of a puppy which still sucked its mother; this strong dose of Physalia had no effect upon it, the tentacles having probably been surrounded by the fleshy parts of the animal in dividing it, so as not to touch the mouth; it seems probable, therefore, that the internal mucus is capable of subduing the irritation, which is so distressing when applied to membranes exposed to the external air. We swallow some things with impunity, which we could not support in the mouth if the burning substance remained there.

"V. I have also procured many 'galleys' since these experiments, and, having placed them in a glass tube, left them to dry and had them pulverised; twenty-five grains of this powder administered to a very young dog produced no deleterious effects. Twice this quantity administered to a young cat produced no more, nor has this surprised me; for, if the fresh animal has no poisonous properties, how can it be supposed that drying the zoophyte can have increased its poisonous properties, if it really possesses them? On the contrary, it is more reasonable to suppose that, by desiccation, the deleterious principle from any animal, whether a Physalia or an Holothurion, should lose infinitely in its principle by evaporation, and by the changes that heat and air produce in the process of drying.

"VI. I have had a 'galley' cut into pieces, and got a fat young chicken to swallow them. It caused no inconvenience. Three hours after, I had the chicken killed and roasted; then I ate it, and made my servant eat it too. Neither of us experienced any inconvenience from it, a certain proof that it is not from eating Physalia that the fish becomes poisonous.

"VII. I put twenty-five grains of powdered Physalia in a little

'bouillon;' I swallowed the dose without the least fear, and I felt no inconvenience from it."

After these experiments, which are certainly quite conclusive, what are we to think of the story related of a certain M. Tébé, the managing partner of a house in Guadaloupe, who fell a victim to his cook, who it is said, after having sought in vain to poison him with the raspings of his nails, which he had spread carefully over the roasted fish daily served up for dinner, determined, seeing that he had signally failed by other means, to put into his soup a pulverised Physalia. An hour after his repast, this gentleman appeared in the burgh of Lamantin, at a little distance from his habitation, and, while entering the city with some friends, he was seized with violent pains in the stomach and intestines, racking him as if by the most corrosive poison. His illness increased until the next day, when he died, under the most excruciating pains. On examination, the stomach and intestines were found to be violently inflamed and corroded, as if he had been poisoned with arsenic, and I have no doubt that it was with this poison, or some other corrosive substance, and not with the Physalia, that M. Tébé really was poisoned. The negroes never make known the substance with which they commit a poisoning; they confess all but the truth, which they are sworn never to reveal —the means they employ, so far as the poisoning material is concerned, are never communicated by confession.

On the other hand, we read in P. Labat's Voyage, vol. ii., p. 31, "that the bécune should not be eaten without some precaution, for this fish being extremely voracious, greedily devours all that comes within its reach in and out of the water, and it often happens that it meets and swallows 'galleys,' which are very caustic, and a violent poison. The fish does not die, but its flesh absorbs the venom, and poisons those who eat it." "There is every reason to believe," says M. Leblond, in the work already quoted, "that the sardine, as well as many other species of fish, after having ate the tentacles of the 'galley,' acquires a poisonous quality. Supping at an auberge on one occasion, with other persons, a bécune was served up, of which gastronomers are very fond, and which is usually perfectly harmless: five persons partook of it, and immediately afterwards exhibited every symptom of being poisoned. This was manifested by a burning heat in the region of the stomach. I bled two of them: one was cured by vomiting; one other would take nothing but tea and some culinary oil. The colic continued during the night, and had disappeared in the morning, but he entertained so great a horror of water, that during the remainder of the voyage a glass of it presented to him

Fig. 49.—Physalia utriculus (Eschscholtz).

made him turn pale." M. Leblond concludes, from this and other facts, that the fishes which eat the Physalia become a poison for those who eat them, although it does not appear that he had any evidence of the fish having ate the "galley," or any other poison.

The habits of the Physalia are still imperfectly known, but among the many strange forms of brilliant colour and elegant contour which swarm in the warmer parts of the ocean, "none," says Gosse, "take a stronger hold on the fancy of the beholder; certainly none is more familiar than the little thing he daily marks floating in the sun-lit waves, as the ship glides swiftly by, which the sailors tell him is the Portuguese man-of-war. Perhaps a dead calm has settled over the sea, and he leans over the bulwarks of the ship scrutinising this ocean-rover at leisure, as it hastily rises and falls on the long, sluggish heavings of the glassy surface. Then he sees that the comparison of the stranger to a ship is a felicitous one, for at a little distance it might well be mistaken for a child's mimic boat, shining in all the gaudy painting in which it left the toy-shop. (Fig. 49.)

"Not unfrequently, one of these tiny vessels comes so close alongside, that, by means of the ship's bucket, with the assistance of a smart fellow who has jumped into the 'chains' with a boat-hook, it is captured, and brought on deck for examination. A dozen voices are, however, lifted, warning you by no means to touch it, for well the experienced sailor knows its terrible powers of defence. It does not now appear so like a ship as when it was at a distance. It is an oblong bladder of tough membrane, varying considerably in shape, for no two agree in this respect; varying also in size, from less than an inch to the size of a man's hat. Once, on a voyage to Mobile, when rounding the Florida reef, I was nearly a whole day passing through a fleet of these little Portuguese men-of-war, which studded the smooth sea as far as the eye could reach, and must have extended for many miles. They were of all sizes within the limits I have mentioned."

Generally, there is a conspicuous difference between the two extremities of the bladder, one end being rounded, the other more pointed, or terminating in a small knob-like swelling or beak-shaped excrescence, where there is a minute orifice; sometimes, however, no such excrescence is visible, and the orifice cannot be detected.

"That wonderful river," continues Mr. Gosse, in his nervous, eloquent style, "with a well defined course through the midst of the Atlantic—the Gulf Stream—brings on its warm waters many of the denizens of tropical seas, and wafts them to the shores on which its waves impinge. Hence it is that so many of the proper pelagic

creatures are from time to time observed on the coasts of Cornwall and Devon. The Portuguese man-of-war is among them, sometimes paying its visit in fleets, more commonly in single stranded hulks. Scarcely a season passes without one or more of these lovely strangers occurring in the vicinity of Torquay. Usually," he adds in a note, "in these stranded examples the tentacles and suckers are much mutilated by washing on the shore. The fishermen who pick them up always endeavour to make a harvest of their capture, not by selling, but by making an exhibition of them."

The Physalia seem to be gregarious in their habits, herding together in shoals. Floating on the sea between the tropics in both oceans, they may be seen now carried along by currents, now driven by the trade-winds, dragging behind them their long tentacular appendages, and conspicuous by their rich and varied colouring, from pale crimson to ultramarine blue. "Certainly," says Lesson, "we can readily conceive that a poetical imagination might well compare the graceful form of the Physalia to the most elegant of sailing-vessels, even if it careened to the wind under a sail of satin, and dragged behind it deceitful garlands which struck with death every creature which suffered itself to be attracted by its seductive appearance."

If fishes have the misfortune to come in contact with one of these creatures, each tentacle, by a movement as rapid as a flash of light, or sudden as an electric shock, seizes and benumbs them, winding round their bodies as a serpent winds itself round its victim. A Physalia of the size of a walnut will kill a fish much stronger than a herring. The flying-fish and the cuttle-fish are the habitual prey of the Physalia. Mr. Bennet describes them as seizing and benumbing them by means of the tentacles, which are alternately contracted to half an inch, and then shot out with amazing velocity to the length of several feet, dragging the helpless and entangled prey to the sucker-like mouths and stomach-like cavities concealed among the tentacles, which he saw filled while he looked on. Dr. Wallich thinks Mr. Bennet must have been mistaken in what he saw; "because he has observed that in a great number of instances the Physalia is accompanied by small fishes which play around and among the depending tentacles without molestation." He has in so many cases seen this, and even witnessed the actual contact of the fishes with the tentacles, with no inconvenience to the former, that he concludes, perhaps too hastily, that the urticating organs are innocuous." "Surely," says Gosse, "the premises by no means warrant such an inference. There is no antagonism between the two series of facts witnessed by such excellent observers; the venomous virulence of these organs has been abun-

dantly proved by many naturalists, myself among the number, and Mr. Bennet to his cost, as already narrated. We can only suppose that the injection of the poison is under the control of the Physalia's will, and the impunity of the bold little fishes is sufficiently accounted for."

Among the numerous specimens of the Physalia captured on our coast, one was obtained at Tenby, by Mr. Hughes, who has given a report of the capture, in which he mentions a circumstance as "normal," which excited Mr. Gosse's curiosity; it was said to be accompanied by "its attendant satellites, two *Velella*." In reply to his inquiries, Mr. Hughes says, "My authority for the association of the Velella with Physalia is Jenkins, the collector of Tenby, who was attending me when it was found. The Physalia was taken by me first; and, while I was admiring it, I noticed that Jenkins continued his search for something. Immediately afterwards he came up with the Velella in his hand, at the same time stating they were generally found with the Portuguese man-of-war. As I had found him very honest and truthful in his dealings with me, I accepted his information as correct."

The Velellinæ assemble together in great shoals; in tropical seas and even in the Mediterranean, and on the western shores of Ireland they may be seen in fine weather floating on the surface of the waves. As described by De Blainville, the body of *Velella spirans* is oval or circular, and gelatinous, sustained in the interior of the dorsal disc by a solid sub-cartilaginous frame, provided on the lower surface of the disk with extensible tentacular cirri. The family includes but two genera; namely, *Porpita* and *Velella*, which the reader will most readily comprehend from the brief description which we shall give of the Mediterranean Velella (*V. spirans*, Fig. 50), which has been very minutely examined by M. Charles Vogt, of Geneva, from whose work on the "Inferior Animals of the Mediterranean" our details are borrowed. *V. spirans*, sometimes called *V. limbosa*, was discovered in the Mediterranean, between Monaco and Mentône, by Forskal, who most erroneously took it for an Holothurion. On the upper surface of the animal is a hydrostatic apparatus, the object of which is to enable it to maintain its equilibrium in the water. This apparatus consists of a shield and a crest, organs of which M. Vogt gives a very detailed description; but it is on the under surface that the principal organs of the Velella are exhibited. These are not seen when the animal swims, because under such circumstances the vertical oblique crest only is visible. The lower surface is concave, with a sort of mesial nucleus, presenting

at the extremity of a trumpet-like prolongation, whitish and contractile, a sort of central mouth, surrounded by tentacular cirri, the external row being much longer than the internal ones. This was formerly thought to be the stomach of the Velella. In the present day, this appendage is known to be the central polyp around which are grouped other whitish and much smaller appendages, the base being surrounded by little yellow bunches. These are supposed to be the reproductive organs. Between the crest and the shield

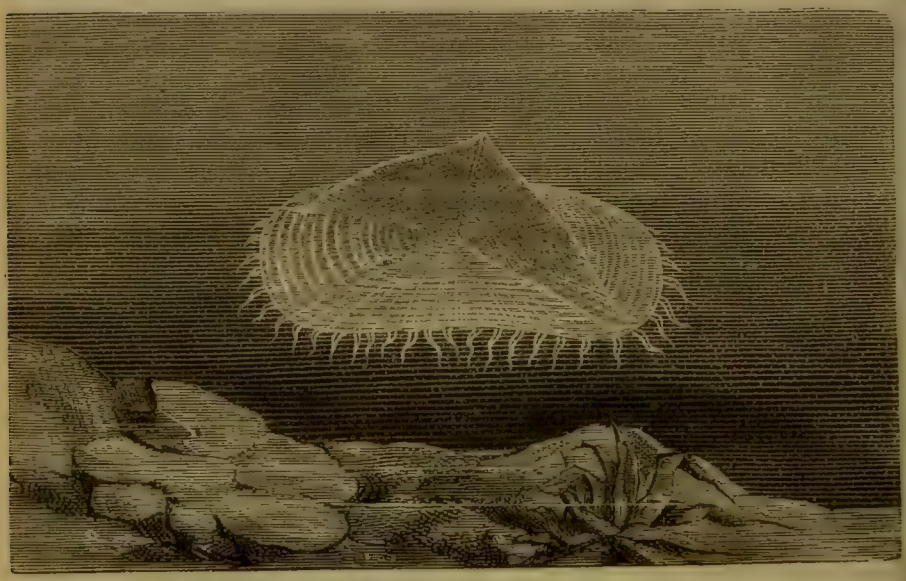


Fig. 50.—Velella spirans (Lamarck).

numerous free tentacles present themselves, vermiform in appearance, cylindrical, and of a sky-blue colour, which are kept in continual motion.

The Velella is therefore not an isolated individual, but a group or colony, in which the individuals intended to be reproductive are the most numerous, and occupy the inferior parts.

The central polyp, by its size and structure, is distinguishable at the first glance from all the other appendages of the lower surface of the body. It is a cylindrical tube, very contractile and spear-shaped, swollen into a round ball, or considerably elongated. Its mouth is round and much dilated; it opens in the cylindrical or trumpet-like part, which is contained in a sac, clothed in the whitish integuments

which formed the body of the polyp when perfect. At the bottom of the sac two rows of openings are observed, which lead to a vascular network extending over the whole body; the membranous parts, while affecting various conditions in their arrangement, are nevertheless in direct communication with all the reproductive individuals.

It is a general characteristic of all colonies of polyps that the digestive cavities of the individuals composing them meet and inosculate in a common vascular system. Velella presents the same conformation. Only in this case the vascular system is extended horizontally, this being the essential character of the union of all the individuals constituting the colony, with the canals common to all, in which the nourishing fluids circulate, elaborated for all and by all. It is a true picture of social communism realised by Nature.

The central polyp is alone destined to absorb the food. M. Vogt has always found in its internal cavity fragments of the shells of crustaceans, the remains of small fishes; and he has often seen the hard parts which resist digestion discharged through the trumpet-like opening. This central polyp nourishes itself and also all the others, but is itself sterile.

The tentacles are hollow cylinders, completely closed at the extremity. They are strong muscular tubes of considerable thickness, the interior of which is filled with a transparent liquid. They are enveloped in a strong membrane of a deep-blue colour. The epidermis is furnished with small stinging capsules, formed of sacs with comparatively thick walls. If one of these sacs is compressed under the microscope it explodes, opening at a determinate part, and throwing out an apparatus in the form of a long stiff filament, which is slightly enlarged at its free end. "I know not," says M. Vogt, "if all this machinery can re-enter the capsule after it has exploded; but I presume that the animal can extend it itself and withdraw at pleasure. A tentacle of Velella sufficiently compressed presents a surface bristling with cirri, so as to resemble a brush. The tentacles themselves are in continual motion, and I have no reason to doubt that the observation of Lesson, who saw them cover small crustaceans and fishes, may be perfectly true. These stinging organs doubtless serve the same purpose as with other animals of the same class; namely, to kill the prey which the tentacles have enabled them to secure." Thus the Velellæ have their javelins, as the Greek and Roman warriors had, and a lasso, as the cavaliers of Mexico and Texas have.

The reproductive individuals form the great mass of the appen-

dages attached to the under surface of the Velella. The form of the individuals is much more varied, inasmuch as they are extremely contractile. Nevertheless, they have considerable resemblance to the corolla of a hyacinth.

These reproductive individuals are at the same time nurses. The Medusæ originating by budding in the case of these reproductive individuals, constitute the sexual state of the Velellæ. They exist, in short, in two alternate states: the one sexual, producing eggs; in this state they are isolated individuals of the Medusidæ, which never group themselves or form colonies; the other aggregate state is non-sexual, and in it they form swimming colonies, under the special designation of *Velella*.

The genus Velella, so called by Lamarck, is found widely diffused in the seas of Europe, Asia, America, and Australia. One species, *V. spirans*, is often taken on the southern coasts of England and Ireland. The animals are also met with far out at sea, and often collected together in considerable masses, old and young together.

Such is a brief account of the strange facts to which the careful study of these lower animals initiates us.

In the genus *Rataria* the body is oval or circular, sustained by a compressed sub-cartilaginous framework, much elevated, having a muscular, movable, longitudinal crest below, and provided in the middle with a free proboscidiform stomach and a single row of marginal tentacular suckers. De Blainville was inclined to consider the very small animals which Eschscholtz termed *Ratariæ* as young and undeveloped *Velella*. M. Vogt sets the matter at rest that the *Rataria* are the young of *Velella*, which have acquired, by little and little, the elliptical form, but that the limb is only furnished at a later period to the reproductive individuals. These Ratariæ are engendered, according to Vogt, by the naked-eyed Medusæ born of the Velellæ, and owe their existence to the eggs produced by these Medusæ.

The second genus *Porpita* consists of colonies of floating animals furnished with a cartilaginous, horizontal, and rounded skeleton, but they are destitute of crest or veil. The body is circular and depressed, slightly convex above, with an internal circular cartilaginous support, having the surface marked by concentric striæ crossing other radiating striæ, the upper surface being covered by a delicate membrane only. The body is concave below; the under surface is furnished with a great number of tentacles, the exterior ones being

longest, and also with small cilia, each terminating in a globule, which sometimes contains air; the interior tentacles are shorter, simple, and fleshy. In the centre of these tentacula is the mouth, in form of a small proboscis, leading to a simple stomach surrounded by a somewhat glandular substance. The editors of the last edition of the "Règne Animal" only mention one species, *P. gigantea*, a native of the Mediterranean and other warm seas, of a beautiful blue colour. Lamarck gives four species. De Blainville and others

Fig. 51.—Porpita pacifica (Lesson).

consider, with Cuvier, that they are only varieties which Eschscholtz reunites under one species. In Fig. 51 we have represented *P. pacifica* (Lesson), the disc of which is twelve lines in diameter, without comprehending the tentacles. This disc is finely radiated on the under surface with a brilliant argentine nacre. The membranous fold which surrounds it is cut into, leaving light and perfectly straight festoons. It is of a clear celestial blue colour, and very transparent. The tentacles are much compressed, very thin and cylindrical, of a light blue, and the glands are of an indigo blue colour. All the reproductive individuals, which are placed in the lower part of the body, are of a perfect hyaline white.

This beautiful Porpita was discovered by Lesson on the Peruvian coast, where it occurred in swarms closely packed on the surface of the sea. "Its manner of life," says Lesson, "is perfectly analogous to that of the Velella. Their locomotion on the sea is purely passive, at least in appearance. Their disc laid flat on the surface upon the water-line, leaves them to float freely and in a horizontal direction, the irritable arms hanging all round them."

Medusidæ.

We here include in this family also the family *Lucernariadæ*. The true Medusidæ were termed by E. Forbes, *Gymnophthalmia*, and the term *Steganophthalmia* was applied to a large section of the *Lucernariadæ*. In the first division, according to Professor J. R. Greene, the umbrella-shaped organ is to be regarded as a nectocalyx, the size and shape of which, in relation to the polypite with which it is connected may also vary very considerably. The veil which surrounds the open margin of the nectosac appears never to be absent. Four longitudinal canals are sometimes present. From the margin depend tentacles, and around the margin are found the vesicles or pigment spots, which are supposed to be eye-spots, and being covered by a prolongation of the nectocalyx. In some genera the tentacles are stiff, and not contractile, as is common in most of the genera. The reproductive organs are of the simplest kind. At a time when the free gonophores of the Hydrozoa had not been perfectly studied, it was the custom to regard these bodies as quite independent organisms, and they were arranged under genera and species. At last the singular resemblance borne by such forms to the *Medusidæ* attracted attention, and it was soon found that many of the *Medusidæ* were not true individual organisms, but merely the reproductive buds of various *Hydrozoa*, and the conclusion was too hastily come to that the whole group of Medusidæ ought to be abolished. The researches of J. and F. Müller, Gegenbaur, and the lamented Claparade, have indicated the probable existence of a group of medusid forms, which appear to be the immediate results of true generative acts, and not of gemmation or fission. It appears safer, in the present state of our knowledge, to conclude—1. That several of the organisms formerly described as *Medusidæ* are the free gonophores of other orders of *Hydrozoa*. 2 That the homology of these free gonophores with these simple expansions of the body-wall which in *Hydra* and some other genera are known to be reproductive organs by their contents alone, is proved alike by the existence of numerous transitional forms, and an appeal

to the phenomena of their development. 3. That many other so-called *Medusidæ* may from analogy be regarded, as in like manner, medusiform gonophores. 4. But that there may exist, nevertheless, a group of medusid forms, which may give rise, by true reproduction, to organisms directly resembling their parents, and therefore worthy of being placed in a separate order, under the name of *Medusidæ*. According to Gegenbaur, the following families would belong to this

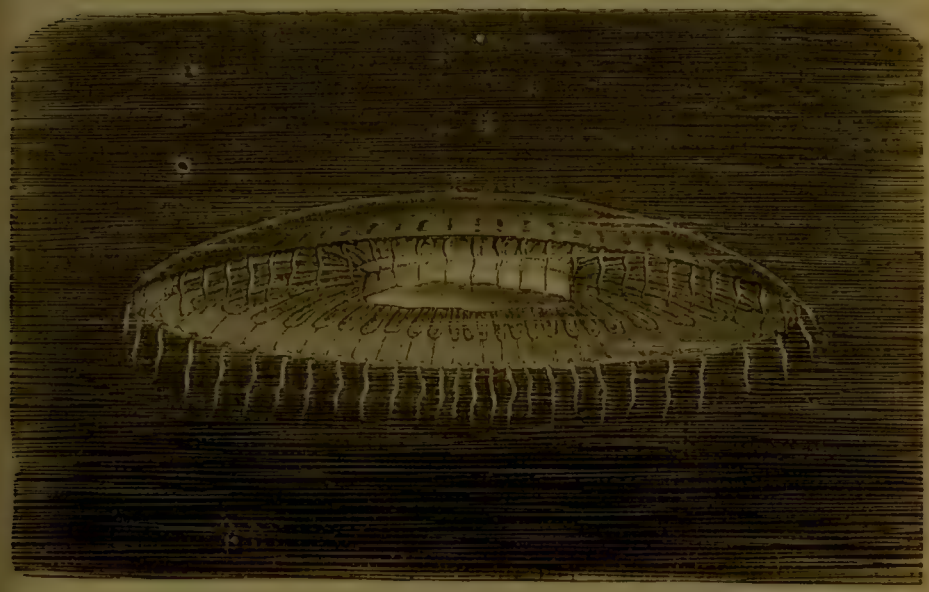


Fig. 52.—Æquorea violacea, natural size (Milne-Edwards).

order:—*Oceanidæ*, *Thaumantidæ*, *Æquoridæ* (Fig. 52), *Eucopidæ*, *Trachynemidæ*, *Geryonidæ*, *Æginidæ*.

In the second division, these included under the family *Lucernariadæ*, the body is more or less cup-shaped, and frequently about an inch in height, terminating proximally in a stalk of variable length, and furnished with a free umbrella, which differs from a nectocalyx, with which it is often confounded, by the absence of a veil, in its mode of development, and in the nature of its canal system, having never less than eight radiating canals, and in the nature of its marginal bodies. If we regard this second division as an order, we may arrange it under two principal sections. In the first, including the genera *Pelagia* and *Lucernaria*, the primary result of the generative

act is the immediate production of an organism which itself is fertile. In the second, including *Rhizostoma*, the result is a fixed and sexless Lucernaroid, which by fission gives rise to zooid forms of disproportionate size, in which the reproductive organs are developed. In the first division one family has the umbrella permanently free; in the other it is furnished with an organ of attachment. Three families of this Lucernariadæ have been defined:—1. *Lucernaridæ.* 2. *Pelagidæ.* 3. *Rhizostomidæ.*

If we walk along the sea shore, after the reflux of the tide, we may often see, lying immovable upon the sands, gelatinous disc-like masses of a greenish colour and repulsive appearance, from which the eye and the steps instinctively turn aside. These beings, whose blubber-like appearance inspires only feelings of disgust when seen lying grey and dead on the shore, are, however, when seen floating on the bosom of the ocean, one of its most graceful ornaments. These are Medusæ. When seen suspended in the middle of the waves, like a piece of gauze or an azure bell, terminating in delicate silvery garlands, we cannot but admire their iridescent colours, or deny that these objects, so forbidding in some of their aspects, rank, in their natural localities, among the most elegant productions of Nature. We could not better commence our studies of these children of the sea than by quoting a passage from the poet Michelet:—"Among the rugged rocks and lagunes, where the retiring sea has left many little animals which were too sluggish or too weak to follow it, some shells will be left there to themselves and suffered to become quite dry. In the midst of them, without shell and without shelter, extended at our feet, lies the animal which we call by the very inappropriate name of the *Medusa.* Why was this name, of terrible associations, given to a creature so charming? Often have I had my attention arrested by these castaways which we see so often on the shore. They are small, about the size of my hand, but singularly pretty, of soft light shades, of an opal white, where it lost itself as in a cloud of tentacles; a crown of tender lilies—the wind had overturned it; its crown of lilac hair floated about, and the delicate umbel, that is, its proper body, was beneath; it had touched the rock—dashed against it; it was wounded, torn in its fine locks, which are also its organs of respiration, absorption, and even of love. . . . . The delicious creature, with its visible innocence, and the iridescence of its soft colours, was left like a gliding, trembling jelly. I paused beside it, nevertheless: I glided my hand under it, raised the motionless body cautiously, and restored it to its natural position for swimming. Putting it into the

neighbouring water, it sank to the bottom, giving no sign of life. I pursued my walk along the shore, but at the end of ten minutes I returned to my Medusa. It was undulating under the wind; it had really moved itself, and was swimming about with singular grace, its hair flying round it as it swam; gently it retired from the rock, not quickly, but still it went, and I soon saw it a long way off."

Of all the forms which live in the ocean there are none more numerous in species or more singular in their structure, more odd in their form, or more remarkable in their mode of reproduction, than those to which Linnæus gave the name of Medusa, from the mythical chief of the Gorgons.

The seas of every latitude of the globe furnish various tribes of these singular beings. They live in the icy waters which bathe Spitzbergen, Greenland, and Iceland; they multiply under the fires of the Equator, and the frozen regions of the South nourish numerous species. They are, of all animals, those which present the least solid substance. Their bodies are little else than water, which is scarcely retained by an imperceptible organic network; their bodies are a transparent jelly, almost without consistence. "It is a true sea-water jelly," says Réaumur, writing in 1701 of a Medusa, "having little colour or consistence. If we take a morsel in our hands, the natural heat is sufficient to dissolve it into water."

Spallanzani could only obtain five or six grains from the pellicle of a Medusa weighing fifty ounces. From certain specimens weighing from ten to twelve pounds, only six to seven pennyweights could be obtained of solid matter, according to Frédol. "Mr. Telfair saw an enormous Medusa (?) which had been abandoned on the beach at Bombay; three days after, the animal began to putrefy. To satisfy his curiosity, he got the neighbouring boatmen to keep an eye upon it, in order to gather the bones and cartilages belonging to the great creature, if by chance it had any; but its decomposition was so rapid and complete that it left no remains, although it required nine months to dissipate it entirely."

"Floating on the bosom of the waters," says Frédol, "the Medusa resembles a bell, an umbrella, or, better still, a floating mushroom, the stalk of which has been here separated into lobes more or less divergent, sinuous, twisted, shrivelled, fringed, the edges of the cap being delicately cut, and provided with long thread-like appendages, which descend vertically into the water like the drooping branches of the weeping willow."

The gelatinous substance of which the body of the Medusa is formed is sometimes as colourless and limpid as crystal; sometimes

it is opaline, and occasionally it is of a bright blue or pale rose colour. In certain species the central parts are of a lively red, blue, or violet colour, while the rest of the body is of a diaphanous hue. This diaphanous tissue, often decked in the finest tints, is so fragile, that when abandoned by the wave on the beach, it melts and disappears without leaving a trace of its having existed, so to speak.

Fig. 53.—Aurelia aurita (Lamarck). Cynea aurita (Cuvier). One-third natural size.

Nevertheless, these fragile creatures, these living soap-bubbles, make long voyages on the surface of the sea. Whilst the sun's rays suffice to dissipate and even annihilate their vaporous substance when cast on some inhospitable beach, they abandon themselves without fear during their entire life to the agitated waves. The whales which haunt round the Hebrides are chiefly nourished by Medusæ which have been transported by the waves in innumerable

swarms from the coast of the Atlantic to the region of whales. "The locomotion of the Medusæ, which is very slow," says De Blainville, "and denotes a very feeble muscular energy, appears, on the other hand, to be unceasing. Since their specific gravity considerably exceeds the water in which they are immersed, these creatures, which are so soft that they probably could not repose on solid ground, require to keep themselves constantly moving in order to sustain themselves in the fluid which they inhabit. They require also to maintain a continual state of expansion and contraction, of systole and diastole. Spallanzani, who observed their movements with great care, says that those of locomotion are executed by the edges of the disc approaching so near to each other that the diameter is diminished in a very sensible degree; by this movement a certain quantity of water contained in the body is ejected with more or less force, by which the body is projected in the inverse direction. Renovated by the cessation of force in its first state of expansion, it contracts itself again, and makes another movement in advance. If the body is perpendicular to the horizon, these successive movements of contraction and dilatation cause it to ascend; if it is more or less oblique, it advances more or less horizontally. In order to descend, it is only necessary for the animal to cease its movements; its specific gravity secures its descent."

It is, then, by a series of contractions and dilatations of their bodies that the Medusæ make their long voyages on the surface of the waters. This double movement of their light skeleton had already been remarked by the ancients, who compared it to the action of respiration in the human chest. From this notion the ancients called them *Sea Lungs*.

The Medusæ usually inhabit the deep seas. They are rarely solitary, but seem to wander about in considerable battalions in the latitudes to which they belong. During their journey they proceed forward, with a course slightly oblique to the convex part of their body. If an obstacle arrests them, if an enemy touches them, the umbrella contracts, and is diminished in volume, the tentacles are folded up, and the timid animal descends into the depths of the ocean.

We have said that the Medusæ constitute in the Arctic seas one of the principal supports of the whale. Their innumerable masses sometimes cover many square leagues in extent. They show themselves and disappear by turns in the same region, at determinate epochs—alternations which depend, no doubt, on the ruling of the winds and currents which carry or lead them. "The barks which

navigate Lake Thau meet," says Frédol, "at certain periods of the year with numerous colonies of a species about the size of a small melon, nearly transparent, whitish like water when it is mixed with

Fig. 54.—Chrysaora Gaudichaudi.

an extract of aniseed. One would be tempted to take these animals at first for a collection of floating muslin bonnets."

The Medusæ are furnished with a mouth placed habitually in the middle of a nectocalyx or of an umbrella. This mouth is rarely unoccupied. Small molluscs, young crustaceans, and annelids, form their ordinary food. In spite of their soft substance, they are most

voracious, and snap up their prey all at one mouthful, without dividing it. If their prey resists and disputes with it, the Medusa which has seized it holds it fast, and remains motionless, and, without a single movement, waits till fatigue has exhausted and killed its victim, when it can swallow it in all security.

In respect to size, the Medusæ vary immensely. Some are very small, while others attain more than a yard in diameter. Many species are phosphorescent during the night.

Most Medusidæ produce an acute pain when they touch the human body. The painful sensation produced by this contact is so general in this group of animals, that it has determined their designation. Until very recently all the animals of the group have been, after Cuvier, designated under the name of Acalephæ, or sea nettles, in order to remind us that the sensation produced is analogous to that occasioned by contact with the stinging leaves of the nettle.

According to Dicquemare, who made experiments on himself in this matter, the sensation produced is very like that occasioned by a nettle, but it is more violent, and endures for half an hour. "In the last moments," says the abbé, "the sensation is such as would be produced by reiterated but very weak prickings. A considerable pain pervaded all the parts which had been touched, accompanied by pustules of a reddish colour with a whitish point."

Their organisation is much more complicated than early observers were disposed to think it. During many ages naturalists were inclined to imagine, with Réaumur, that the Medusæ were mere masses of organised jelly, or, as it were, of gelatinised water. But when Courtant Dumeril tried the experiment of injecting milk into their cavities, and saw the liquid penetrating into true vessels, he began to comprehend that these very enigmatical beings were worthy of further study; and the study of subsequent naturalists, such as Cuvier, De Blainville, Ehrenberg, Brandt, Eschscholtz, Sars, Milne-Edwards, Forbes, Gosse, and other recent naturalists, have demonstrated what richness of structure is concealed under the gelatiniform and simple structure to be met with in the Medusæ; at the same time they have revealed to us most mysterious and incredible facts in connection with their metamorphoses. Among the Medusæ proper, that is the *Gymnophthalmata*, we find the genus *Æquorea*. *Æ. violacea* is figured on page 157 (Fig. 52). Of the genera belonging to the *Steganophthalmata* among the most common are Pelagia and Chrysaora. In the former genus we find *P. noctiluca*. In the latter, *C. Gaudichaudi* (Fig. 54), the disc is hemispherical, festooned with numerous tentacles, attached to a sac-like stomach, opening by a

single orifice in the centre of the peduncle, with four long, fur-belowed, unfringed arms. Gaudichauds Chrysaora is found round the Falkland Islands. The disc forms a regular half-sphere, very

Fig. 55.—Rhizostoma Cuvierii.

smooth, and perfectly concave, forming a sort of canopy in the shape of a vault. The circle which surrounds it is divided into sections by means of vertical lines, regularly divided, of a reddish-brown colour, which form an edging to the umbrella-like disc. Twelve broad regular festoons form this edging. From the summit of these lobes issue twelve bundles of very long, simple, thread-

like tentacles, of a bright red. The peduncle is broad and flat, perforated in the middle, to which are attached four broad foliaceous arms. *Cyanea aurita* is figured on page 160.

Fig. 56.—Rhizostoma Aldrovandi.

In the genus *Rhizostoma* the disc is hemispherically festooned, depressed, without marginal tentacles, peduncle divided into four pairs of arms, forked, and divided almost indefinitely, each having at their base two toothed auricles. Such is *Rhizostoma Cuvierii* of Péron (Fig. 55), the disc of which is of a bluish-white, like the arms, and of a rich violet over its circumference. This beautiful form is found

plentifully in the Atlantic, living in flocks, and attains a great size. It is common in the month of June on the shores near Saint Malo; in August on the English coast; and along the strand of every port in the Channel they are to be seen in the month of October in thousands, where they lie high and dry upon the shore, on which they have been thrown by the force of the winds.

Fig. 57.—Cassiopea andromeda (Tilesius).

R. Aldrovandi (Fig. 56) is also common, and is to be met with all the year round in calm weather. It is an animal much dreaded by bathers. It possesses a stinging apparatus, which produces an effect similar to the stinging-nettle when applied to the skin. If the animal touches the fisherman at the moment of being drawn from the water, it is apt to inflame the part that it touches and raise it into pustules.

Fig. 58.—Cephea cyclophora.

Cassiopea and *Cephea* are two other genera belonging to the same group. In *Cassiopea andromeda* (Fig. 57), the disc is hemispherical, but much depressed, without marginal tentacles or peduncle, but with a central disc, with four to eight half-moon-shaped orifices at the side, and throwing off eight to ten branching arms, fringed with retractile sucking discs. *Cephea cyclophora*, Péron (Fig. 58), is another very remarkable form of these strangely-constituted organisms.

Having presented to the reader these few characteristic types of Medusidæ, we proceed to offer some general remarks upon the organisation and functions of these strange creatures. We have, in short, selected these types because they have been special objects of anatomical and physiological study to some of our best naturalists.

The Medusæ have no other means of breathing but through the skin. We remark all over the body of these creatures certain prolongations of the tegumentary system, disposed perhaps so as to favour the exercise of the breathing function. Certain marginal fringes of extended surface, as well as the tentacles, may be the special seats of this function. The organs of digestion also present arrangements peculiar to themselves; the mouth is placed on the lower part of the body, and is pierced at the extremity of a trumpet-like tube, hanging sometimes like the tongue of a bell. The walls of the stomach, again, are furnished with a multitude of appendages, which have their origin in the cavity of the organ, and which are very elastic. The stomach, furnished with vibratile cilia, appears to secrete a juice whose function is to decompose the food and render indigestible.

A very distinct circulation exists in the Medusæ. The peripheric part of the stomach suffers the nourishing liquid which has been elaborated in the digestive cavity to pass; this fluid then circulates through numerous canals, the existence of which have been clearly traced.

It is also a singular fact, that organs of sense seem to have been discovered in these Medusæ, which early observers believed to be altogether destitute of organisation. "During my sojourn on the banks of the Red Sea," says Ehrenberg, in his Memoir on the *Medusa aurita*, "although I had many times examined the brownish bodies upon the edge of the disc of the Medusæ, it is only in the past month that I have recognised their true nature and function. Each of these bodies consists of a little yellow tubercle, oval or cylindrical, fixed upon a thin peduncle. The peduncle is attached to a vesicle, in which the microscope reveals a glandular body, yellow when the light traverses it, but white when the light is only reflected on it. From this body issue two branches, which proceed towards the

peduncle or base of the brown body up to the head. I have found that each of these small brown bodies presents a very distinct red point placed on the dorsal face of the yellow head; and when I compare this with my other observations of similar red points in other animals, I find that they greatly resemble the eyes of the Rotifera and Entomostraca. The bifurcating body placed at the base of the brown spot appears to be a nervous ganglion, and its branches may be regarded as optic nerves. Each pedunculated eye presents upon its lower face a small yellow sac, in which are found, in greater or smaller numbers, small crystalline bodies clear as water." The presence of a red pigment in very fine grains is an argument in favour of the existence of visual organs in these creatures, for the small crystals disseminated in the interior of the organ would no doubt perform the part of refracting light which is produced by the crystalline lens in the eyes of vertebrated animals. Moreover, it is found that there are marginal corpuscles analogous to these brown spots in other species of Medusæ. They are of a palish yellow, or quite colourless, and enclose sometimes a single, sometimes many calcareous corpuscles. When they are colourless, some naturalists have rather taken them for organs of hearing reduced to their most simple expression.

The Medusæ are not, according to Agassiz, absolutely destitute of nervous system. We have seen that they may have ganglions, and probably optic nerves. Ehrenberg also states that these have ganglions at their base, which furnish them with nervous filaments.

Without entering further into the details of their delicate and complicated structure, we shall pause briefly on their mode of reproduction. We shall find here physiological phenomena so remarkable as to appear incredible, had not the researches of modern naturalists placed the facts beyond all doubt. "Which of us," says M. de Quatrefages, "would not proclaim the prodigy, if he saw a reptile issue from an egg laid in his court-yard, which afterwards gave birth to an indefinite number of fishes and birds? Well, the generation of the Medusæ is at least as marvellous as the fact which we have imagined." Let us note, for example, what takes place with the Rose Aurelia, a beautiful Medusa, of a pale rose colour, with nearly hemispherical disc, from four to five inches in diameter, whose edge is furnished with short russet-brown tentacles; taking for our guide the eloquent and learned author of "Metamorphoses in Man and the Lower Animals," M. de Quatrefages.

The Medusa designated under the name of Rose Aurelia lays eggs which are characterised by the existence of three concentric

spheres. These eggs are transformed into oval larvæ, covered with vibratile cilia, having a slight depression in front. They swim about for a short time with great activity, much like some of the Infusoria, which they strikingly resemble in other respects.

At the end of forty-eight hours their movements decrease. Aided by the depression already noted, the larval form attaches itself to some solid body, fixing itself to it at this stage by the presence of a thick mucous matter. A change of form soon takes place: it becomes elongated; its pedicle is contracted, and its free extremity swells into a club-like shape. An opening soon presents itself in the centre of this extremity, through which an internal cavity appears. Four little protuberances have now appeared on the edge, which are in time elongated in the manner of arms. Others soon follow: these are the tentacles of a polyp: the young infusorian has become a polyp!

The polyp increases by buds and shoots, just like a strawberry plant, which throws out its slender stems in all directions, covering all the neighbouring ground.

The young Medusa lives some time under this form. Then one of the polyps becomes enlarged and its form cylindrical. This cylinder is divided into from ten to fourteen superimposed rings. These rings, at first smooth, form themselves into festoons, and separate into bifurcated thongs; the intermediate lines become channeled. The animal now resembles a pile of plates, cut round the edges. In a short time each ring is slightly raised at the free edge of its fringe: this then becomes contractile. The rings are individualised. Finally, these disc-shaped creatures isolate themselves. When detached, they begin to swim: from that time they have only to perfect and modify their form. From being flat, they become concave on the one side and convex on the other. The digestive cavity—the gastro-vascular canals—become more decided; the mouth opens on the concave surface; the tentacles are elongated; the floating marginal cirri become more and more numerous; and now, after all these metamorphoses, the Medusa appears; it perfectly resembles, not the parent form, but that from which its parent form originally sprung.

CHAPTER VII.

ZOANTHARIA.

"I saw the living pile ascend
The mausoleum of its architects,
Still dying upwards as their labour closed:
Slime the material, but the slime was turned
To adamant by their petrific touch."

MONTGOMERY'S *Pelican Island.*

THE creatures which constitute the class *Zoantharia* are quite great personages. Some of them are eighteen or twenty inches long; at the same time, others scarcely exceed the eighth part of an inch in length. They live in all seas, and seem to have existed through many ages of the earth's history; they appear at an early geological period, and they have performed an important part in its formation.

The name of *Zoantharia* was first given to the class by Dr. J. E. Gray; but here we give it a somewhat wider signification, embracing under it the madrepores and starred stones of Lesueur, who was reminded of a field enamelled with small flowers when he saw the little polyps of *Porites astroïdes* in full blow. "But it is only," says Johnston, "when they lie with their upper disc expanded, and their tentacula displayed, that they solicit comparison with the hosts of Flora; for, when contracted, the polyps of the madrepores conceal themselves in their calcareous cups, and the actinia hide their beauty, assuming the shape of an obtuse cone or hemisphere of a fleshy consistence, or elongating themselves into a sort of flabby cylinder that indicates a state of relaxation and indolent repose."

These zoantharia are flesh-eaters, and consume quantities truly prodigious of animals such as crustaceans, worms, and small fishes. They are all marine, nearly all attached to the same spot for life, and they live in colonies. Some few are isolated and live by themselves, either free or attached to the soil. They differ altogether from the animals belonging to the *Alcyonaria* by the number and peculiar form of their tentacula. These appendages in the *Zoantharia* never present the *bipinnate* arrangement which is observable in the *Alcyonaria.*

They are habitually simple, and, if they present ramifications, these are only exceptional. In nearly every instance, the tentacles exist to the number of twelve, eighteen, twenty-four, and even larger numbers, and they form a sort of concentric crown to the animal.

Zoanthus thalassanthos (Lesson), which has given its name to the group, consists of large turf-like tufts of coral attached to a rock. Its polyps are packed close together, and their expanded flower-like heads have a curious resemblance to a mass of flowers in full bloom. They are borne on bending root-like stems of pure white, interlacing one with the other, surmounted by a fusiform or spindle-shaped body, pediculate and swelling towards the middle, but truncate at the summit, of a reddish-brown colour, marked with longitudinal stripes more highly coloured; its consistence is firm and parchment-like. From the body issues a tube, narrow, muscular, contractile, and red in colour, terminating at the summit in eight elongated arms or tentacula, of a pure yellow, traversed by a nervure of the same colour. The edges of these arms are fringed with fine pinnæ, parallel to each other, of a bright maroon colour, and resembling the barbs of a feather. According to Lesson, the arms of this *Zoanthus* are kept unceasingly in motion, thus producing in the water small oscillating currents, in the course of which the animalcules on which the polyps feed are precipitated into the stream leading to their mouths.

The tendency to produce a calcareous or horny polypidom is a property almost universal with animals of this class. Zoologists are agreed in dividing them into three very distinct orders—namely, the ANTIPATHIDÆ, consisting of the genera *Antipathes*, *Cirripathes*, and *Leipathes*, in which the polypidom is of a horny consistence; the MADREPORIDÆ, in which the polypidom is calcareous and stony; finally, the ACTINIDÆ, which produce no true polypidom.

ANTIPATHIDÆ.

We need not dwell upon this group, which is comparatively uninteresting. They somewhat correspond with the family of *Gorgonidæ* among the *Alcyonaria*, which they resemble in having the central axes branching after the manner of a shrub; but the polyps have the mouth surrounded with a crown of six simple tentacula. The axis is of a harder and denser tissue than that of the Gorgonidæ, and presents on its surface small spiniform projections. The polypiferous crust, with which they are covered, is in general very arenaceous, and is so easily detached, that it is rare to see in collections anything but the denuded skeleton of the colony. In *Antipathes arborea*, the

polypidom is fragile and brittle; when dry, the branches, always slender and delicate, resemble the barbs of a feather. The colour is of a deep black, or rather bistre and *terra de sienna* tint. Under a powerful lens, the extremities of the branches appear to be covered with small spines, and the stem is formed of oval and irregular concentric layers, which are so many zones of growth. Its consistence is solid, so that it can be worked up and converted into chaplets for pearls and other bijouterie: it is known in commerce as *black coral.*

MADREPORIDÆ.

The *Madrepores* are better known than their congeners. They are sometimes designated corals, but it must be recollected that the precious coral forms no part of this group.

The Madrepores are remarkable for the calcareous secretion which always surrounds their tissue, and determines the formation of their polypidom. They are in other respects easily recognised by the star-like structure of their polypidom, in which may always be distinguished a visceral chamber, the circumference of which is furnished with perpendicular laminæ or partitions, which are always directed towards the axis of the body. When sufficiently developed they constitute, by their assemblage, a star-like body formed of a great number of rays. The polypidom is always calcareous. The consolidation of the envelope of each polyp produces at first a kind of sheath, to which Milne-Edwards has given the name of "the wall." The partitions which proceed from the interior towards the axis of the visceral chamber occupy the subtentacular cells; the terminal and open portion designated the calyx is in organic continuity with the polyp, which has retired thither more or less completely, as into a cell.

Milne-Edwards remarks that the polypidom of the *Madreporidæ* present in their structure five principal modifications, due in part to the fundamental number of which the chambered cells are the multiple, and in part to the mode of division of the visceral chamber, and finally to the manner in which its tissue is constituted M. Edwards avails himself of this peculiarity of structure in order to divide the Madrepores into five sections—namely, *Madrépores apores*, *Madrépores perforés*, *Madrépores tabulés*, *Madrépores tubulés*, and *Madrépores rugueux.*

In the group of APOROUS MADREPORES, the polypidom is perhaps the most highly organised. We find there a well-developed and very perfect wall, and a well-developed visceral apparatus. The calyx is symmetrically rayed; the number of rays in the earlier stages being six, which soon afterwards reaches from twelve to twenty-

four. The cells between the chambers are sometimes open in all their depth, sometimes more or less shut up by transverse plates; these, being independent of each other, are never reunited in the breadth of the visceral cavity, so that they constitute discoid plates such as we find in the *tabular* and *rugose* Madrepores. The animals belonging to this group, which may be characterised as *stelliform* or star-like, are very abundant in every sea, and in several geological formations. They constitute many genera, among which may be noted the *Milleporina* of Ehrenberg, the polypidom of which Dr. Johnston describes as "calcareous, fixed, plant-like, branching or lobed, with cells scattered over the whole surface, distinct, sunk in little fosses, obscurely stellate, the lamellæ narrow and almost obsolete."* In *Turbinolia*, the animal is simple, conical, striped, furrowed externally with larger and smaller ribs, the mouth surrounded by numerous tentacula, and solidified by a calcareous polypidom, which is free, conical, and also furrowed externally; attenuated at the base, but enlarged at the summit, and terminating in a shallow radiated lamellar cup or cell. Several specimens of *T. milletiana* have been dredged off the coast of Cornwall, and the west coasts of Scotland and Ireland.

T. milletiana is described as being coral-white, wedge-shaped, somewhat compressed, with interspaces or ribs equidistant, smooth, and glossy. Above, the ribs turn over the edge, and are continued into the centre of the enlarged cup, forming its lamellæ. "That the zoophyte must have lived for some time after having become a movable thing, is proved," says Dr. Johnston, "by the ribs being continued beyond or round the point of attachment." The specimen here described was dredged alive; and Prof. Forbes says of it that "it is a most interesting and beautiful species, the more so as it is certainly identical with Defrance's *Turbinolia milletiana*, found in both the crag formations."

In the sub-family of the Zoanthidæ, the polypes occur in clusters, and are multipled by buds, rising from a common creeping, root-like, fleshy base; they thus present a sort of coriaceous polypidom, as in *Zoanthus* (Fig. 59). In the British Channel the species which Dr. Johnston has named *Z. Couchii*, after Mr. Couch, jun., is found along the Cornish coast, on flat slates and rocks, in deep water, and from one to ten leagues from the shore. It is very small, resembling both in shape and size a split pea. When living, its surface is plain but glandular, becoming corrugated when preserved. When semi-expanded, which is its favourite state, it elevates itself to twice its

* Johnston's "Zoophytes," vol. i., p. 194

ordinary height, becoming contracted about the middle, like an hour-glass. When the creature is fully expanded, the tentacula become distended and elongated to about the length of the transverse diameter of the body; and they are generally darker at their extremities than towards the base. The present species possesses a power of considerably altering its shape; sometimes the mouth is depressed, and at others it is elevated into an obtuse cone. "This is one of the most inactive of its order," says Mr. A. Couch; "for, whether in a state of contraction or expansion, it will remain so for

Fig. 59.—Zoanthus socialis (Cuvier), magnified.

many days without apparent change. In its expanded state a touch will make it contract, and it will commonly remain so for many days." The trailing connecting-band is flat, thin, narrow, glandular, and of the same texture as the polyp, sometimes enlarging into small papillary eminences, which, as they become enlarged, become developed into polyps.

The genus *Caryophillia* (Lamarck), from καρύον, a nut, and φύλλον, a leaf, has the polypidom permanently fixed, simple, striated longitudinally, and the summit hollowed into a lamellated star-like cup; the animal, actinia-like, is provided with a simple or double crown of tentacula, projecting from the surface of star-like, cylindrical, cone-shaped

cells. In *C. cyathus*, Lamarck (Fig. 60), which inhabits the Mediterranean, and is common on some parts of the English and Irish coast, the polyps are of a whitish colour, the tentacula streaked with grey. The polypidom is erect and upright, sometimes cylindrical, and generally so firmly attached to the rock as to seem a part of it. The lamellæ are of three kinds: one row large and prominent, between every pair of which there are three, sometimes five, smaller ones, the centre one being divided into two portions forming an inner series. The lamellæ are slightly arched entire and striated on the sides,

Fig. 60.—Caryophillia cyathus (Lamarck).

whence the margin appears somewhat crenulated. "It is found," says Mr. Couch, "of all sizes, from a mere speck to an inch in height. In a very young state, it is sometimes found parasitical on *Alcyonium digitatum*, on shells, and on stalks of sea-weeds; but as these substances are very perishable, and offer no solid foundation, large specimens are never found on them. In its young state the animal has but little of a calcareous skeleton, and measures about the fifteenth of an inch in diameter and about the thirtieth of an inch in height. In the earliest state in which I have seen the calcareous polypidom, there were four small rays, which were free or unconnected down to the base; in others I have noticed six primary rays.

but in every case they were unconnected with each other. Other rays soon make their appearance between those first formed; they are mere calcareous specks at first, but afterwards increase in size. The first union of rays is observed as a small calcareous rim at the base of the polyp, which afterwards increases in height and diameter with the age of the animal."

The animals of this interesting polypidom are vividly described by Dr. Coldstream, in a communication to Dr. Johnston, as he observed them at Torquay :—

"When the soft parts are fully expanded," he says, "the appear-

Fig. 61.—Flabellum pavonium (Lesson).

1. Seen from the side. 2. Upper surface, with its plates and median furrow. 3. Animal, with tentacles expanded.

ance of the whole animal closely resembles an actinia. When shrunk, they are almost entirely hid amongst the radiating plates. They are found pendent," he adds, "from large boulders of sandstone, just at low-water mark. Sometimes they are dredged from the middle of the bay. Their colour varies considerably. I have seen the soft parts white, yellowish, orange-brown, reddish, and of a fine apple-green. The tentacula are usually paler."

Species of this genus are sometimes dredged from great depths; Professor Travers dredged one in eighty fathoms, and Dr. Johnston remarks that the existence of an animal so vividly coloured at so great a depth is worthy of remark. "When taken," says the professor, "the animal was scarcely visible, being contracted; when expanded, the disk was conspicuously marked by two dentated

circles of bright apple-green, the one marginal and outside the tentacula, the other at some distance from the transverse and linear mouth. In the dark, the animal gave out a few dull flashes of phosphorescent light."

As belonging to this family, we present illustrations of *Flabellum pavonium*, Lesson (Fig. 61).

Fig. 62.—Oculina virginea (Lamarck).

Of the genus *Oculina*, the animal is unknown, but it is contained in regular round radiated cells, more or less prominent, and scattered on the surface of a solid, compact, fixed tree-like coral. The individuals dispose themselves in ascending spiral lines, and appear to be regularly dispersed on the surface of the several branches. The typical species, *O. virginea* (Fig. 62), formerly known as the White

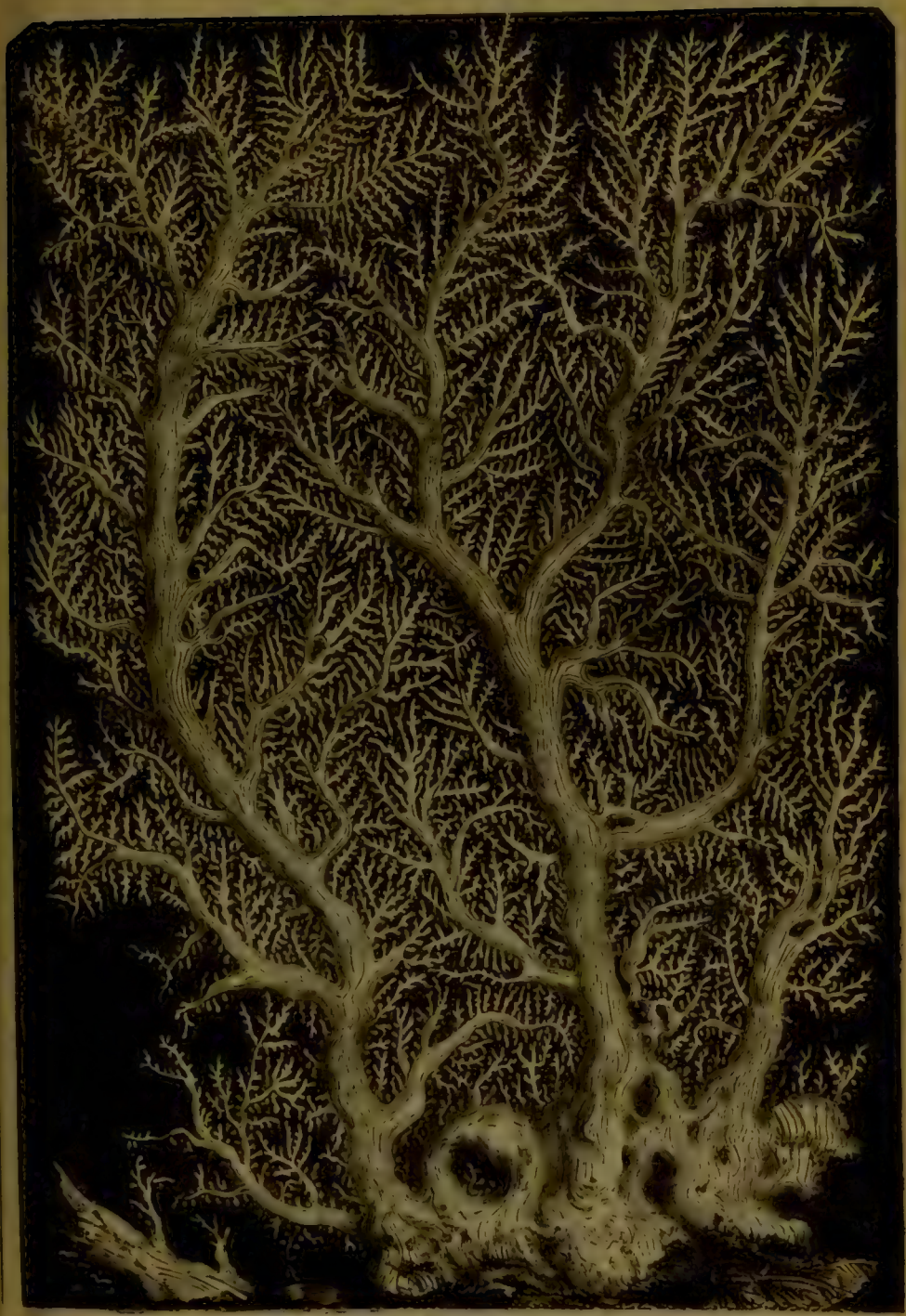


Fig. 63.—Stylaster flabelliformis (Lamarck).

Coral, although it differs widely in structure from the precious Coral, is found in the Mediterranean and also in the tropical seas. In 2, Fig. 62, we see a portion of a branch magnified, so that the reader may be able to appreciate the form of the polyp cells.

The species formerly referred to in this genus as *Oculina flabelliformis*, now bearing the name of *Stylaster flabelliformis*, which is represented in Fig. 63, will give an excellent idea of these arborescent madrepores. The polypidom is in the form of a fan, with many very unequal branches: the larger branches are smooth, the middle-sized are covered with small points. This fine madrepore is found in the

Fig. 64.—Astreopora punctifera (Lamarck).

seas which surround the Isle of Bourbon and the Mauritius, fine examples of which are to be seen in almost all large public museums.

How diversified are the forms of aquatic life! "Nature revels in these diversities," to paraphrase the saying of one of the ancient kings of France. Here are animals, the skeletons of which might have been designed by a geometrician. They are called Star Corals (*Astræa*). Their resemblance to a perfectly regular star was too striking to escape the observation of the naturalist; but the organisation of these creatures of the ocean is far from being rigorously regular, for Nature rarely employs perfectly straight lines, giving an evident preference to circles and waving lines.

The *Astreidæ* form an immense section of the aporous Madre-

pores; they are inhabitants of the tropical and semi-tropical portions of the great oceans, where they are found in a great variety of forms, which has led to its subdivision into two great divisions consisting of very many genera by Messrs. Milne-Edwards and J. Haime. The animals are short, more or less cylindrical, with a rounded mouth

Fig 65.—Meandrina cerebriformis (Lamarck.

placed in the centre of a disc, covered with a few rather short tentacula; they form by their union a variously-shaped coral, which often encrusts other bodies.

The genus *Meandrina* differs from that of *Astræa* in having the surface hollowed out into shallow sinuous elongated cells, furnished on each side of the mesial line with crenulated lamellæ, the columella is but little developed; the polypidom, which, like all the group, is

calcareous, being fixed, simple, conical when young, and globular when old. The animals have lateral series of short tentacula around a distinct mouth; they are contained in shallow cells, meeting at the base, and forming by their union long and tortuous sulci. *Meandrina* (*Diploria*) *cerebriformis* (Fig. 65), so called from its resemblance to the convolutions of the brain, is a native of the American Seas.

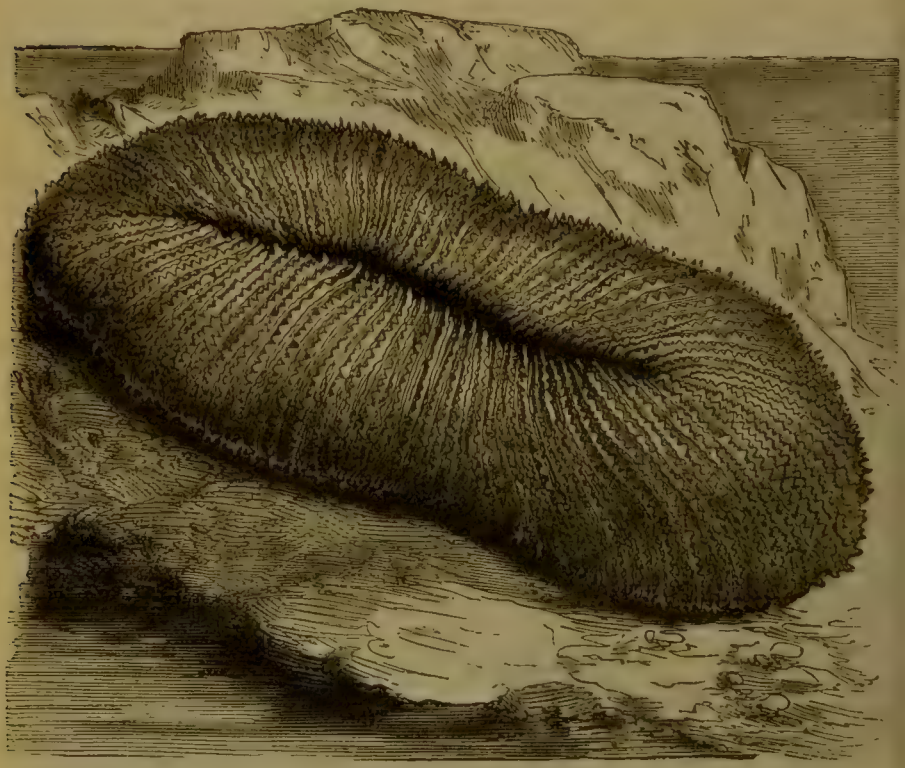


Fig. 66.—Fungia echinata (Milne-Edwards).

The genus *Fungia*, so called by Lamarck from the resemblance of the species to the vegetable Fungi, presents forms too remarkable in their appearance to be passed over in silence. All the species of this genus occur in a living state. Nevertheless some species of closely-allied genera are very numerous in the Cretaceous period.

The genus, as we have already said, takes its name from its supposed resemblance to a Mushroom. "But," says Peyssonnel, "there is this difference between terrestrial and marine mushrooms—

that the former have leaflets below, and those of the ocean have them above (Fig. 66). These leaflets are only expansions of the Madrepores. Now, although I have not actually examined these stony Mushrooms of the sea, I have no reason to doubt but that they are true genera or species of Madrepores, containing, like others, the animals which form them. In my travels in Egypt, in 1714 and

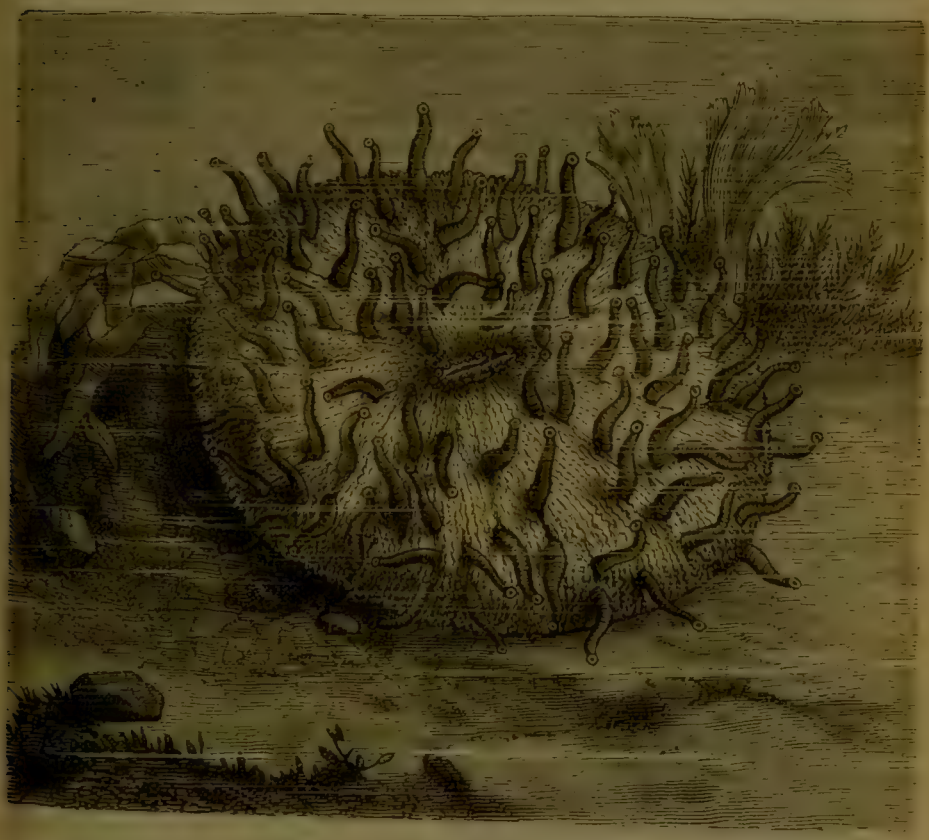


Fig. 67.—Fungia patella (Lamarck).

1715, I never heard it said that the Nile could produce them." In this last remark, Peyssonnel makes allusion to the opinion entertained by many ancient authors, that the Fungia were productions of the Nile.

The animal is depressed and oval, with mouth superior and transverse, in a large disc, which is covered by many thick cirrhiform tentacula; the polypidom is rendered solid internally by a calcareous

deposit which has the appearance of a star of radiating acutely-pointed lamellæ above, and simple rays, full of wrinkles, beneath. There are several species, mostly natives of the Pacific and Indian Oceans and Red Sea, which De Blainville arranges in three groups, according as they are simple and circular, simple and compressed, or complex and oblong. In *Fungia echinata*, represented in Fig. 66, we have a species which inhabits the Indian and Chinese Seas. It belongs to the last group, being oblong in form, convex above, and concave below. The hollow, from which the lamellæ or chamber-walls proceed, are of considerable length; the toothed partitions are very irregular, thin and prickly, resting upon their lower edge, leaving the concave portion of the field free to a crop of excrescences, resembling the roof of a grotto studded with small stalactites.

The appearances presented by the soft parts of the polyps have been described by many travellers. The upper portion of the body of the animal, corresponding to the lamelliform part of the polypidom, is furnished with scattered tentacula, very long in some species, and remarkably short in others, these tentacula appear to terminate in a small sucker. In order to complete our description of these curious madrepores, we may refer to *Fungia patella*, represented in Fig 67. This remarkable species inhabits the Red Sea and the Indian Ocean, and is here represented with its polyps.

De Blainville gave the name of MADREPORÆA to the second group of the stony *Zoantharia*, and they correspond to the *Madrepores perforés* of Milne-Edwards. The skeletons of this section are generally arborescent, with small, partially lamelliform cells, which are constantly porous in the interstices of the walls of the cells, this being their most important characteristic. Thus, the polyps present no side plates, the visceral chamber being open from the base to the summit, and is neither filled with dissepiments nor with plates.

The history of these inhabitants of the deep is extremely obscure, the most beautiful of the species are intertropical, and consequently were for a long time beyond the reach of discriminating observers during the life of the animal. Solander proposed to divide the group according to certain characteristics in the growth of the coral, and De Blainville has re-arranged the groups formed by Lamarck, Lamouroux, and Goldfuss, with special reference to the structure of the soft parts of the animals figured by Lesueur, Quoy, Gaimard, and others, who have observed them in a recent state.

The perforated *Zoantharia* form two very natural families: the *Madreporinæ* and the *Poritinæ*. The first have the solid parts of the

polyps simple or complex, with well-developed lamellar portions, the central column spongious, walls granular, semi-ribbed, and perforated; the second have a reticulated sclerenchyma, septa more or less distinct, the visceral chambers containing sometimes small rudimentary plates.

Fig. 68.—Dendrophyllia ramea, half natural size De Blainville).

We shall describe three genera, the two first of which belong to the *Madreporinæ*, and the last to the family of the *Poritidæ*.

Dendrophyllia ramea, represented in Figs. 68, 69, and 70, is an elegant madrepore of the Mediterranean. Its polypidom presents a very large stem with short ascending branches; it often attains to about

two feet in height. The polyps are provided with a great number of tentacula, in the centre of which the mouth is placed; they are deeply buried in the cells. Peyssonnel, who had seen the polyps forming one of such a colony, says: "I may observe that the extremities or summits of the branching madrepore, the species in question, which in the Provençal we call 'sea-fennel,' is soft and tender, filled with a glutinous and transparent mucous substance, similar to that which the snail leaves on its path. These extremities

Fig 69.—Dendrophyllia ramea (De Blainville). Natural size, with polypi.

Fig. 70.—A part magnified.

are of a fine yellow colour, five or six lines in diameter; soft, and more than a finger's breadth in length. I have seen the animal nestling in them; it seemed to be a species of cuttle-fish or sea-nettle. The body of this sea-nettle must have filled the centre; the head being in the middle, surrounded by many feet or claws, like those of the cuttle-fish. The flesh of this animal is very delicate, and is easily reduced to the form of a paste, melting almost under the touch."

The madrepores abound in all intertropical seas, taking a considerable part in the formation of the reefs which form the coral and madreporic islands so conspicuous in the three oceans. The tree-like *Dendrophyllia* (*D. ramea*, Figs. 68, 69, and 70) have cells of con-

siderable depth, radiating into numerous lamellæ, forming a widely-branching arborescent coral, externally striated, internally furrowed, and truncate at the extremities. The animals are actiniform, furnished with numerous pinnate tentacula, in the centre of which is the polygonal

Fig. 71.—Madrepora plantaginea (Lamarck).

mouth. In *Lobophyllia*, the tentacula are cylindrical, the cells conical, sometimes elongated and sinuous, with a sub-circular opening terminating the few branches of the polyp, which is fixed, turbinate, and striated. The Plantain Madrepore, *Madrepora plantaginea* (Lamarck), is an interesting species, the polyps presenting themselves, as in Fig. 71, in tufts, with slender and prolific branches.

In *Madrepora palmata*, vulgarly named Neptune's Car, we have a large and beautiful species, whose expanding branches are flat, round at the base, and formed into lobes, whose length is often as much as three feet high, with a breadth of twenty inches, and a

Fig. 72.—Porites furcata (Lamarck), natural size.

thickness of two to two and a half: this fine madrepore is found in the Caribbean Sea and among the Antilles.

Here also comes *Astreopora punctifera*, Fig. 64, p. 180.

The genus *Porites* belong to the second family Poritinæ of the perforated madrepores, the polypidom is entirely formed by a reticulated sclerenchyma, the animal is somewhat pitcher-shaped, with twelve short tentacula; the cells are unequally polygonal, imperfectly

defined, slightly radiating by thread-like pointed rays, with papilla placed at intervals. The polypidom is polymorphous or many-formed, composed of a reticulated and porous tissue, the individuals forming it being always completely united together. Externally it presents

Fig. 73.—Millepora alcicornis (Linn.), one-fourth natural size

the figure of an irregular trellis-work, more or less loosely connected in its meshes. As a type of this organisation, we give a figure of the Forked Porites (*P. furcata*, Fig. 72), of the natural size. The branches are generally dichotomous, that is, rising in pairs obtusely lobed. In some of the species the rays are more fully marked, and resemble a bed of miniature anemones thickly crowded together, as in *Goniopora columna*, from the Fiji Islands, in which the polyps have a central mouth, round which the twelve short tentacula radiate; the coral is

stony, fixed, branched, or lobed, having a free surface covered with a great number of regular stars.

In the TABULATE MADREPORES, the polypidom is essentially composed of a highly-developed mural system. The visceral chambers are divided into a series of stages or stories, by perfect diaphragms or plates placed transversely, the plates depending from the walls and forming perfect horizontal divisions, extending from one wall of the general cavity to the other. In order that the reader may form some idea of the Tabulate Madrepores, one of the commonest forms is here (Fig. 73) represented. The millepores were first separated from the madrepores by Linnæus, along with a great number of species distinguished by the minuteness of their pores or polypiferous cells.

Millepora moniliformis is a species which attaches itself to the branches of some of the Gorgonidæ, forming there a series of little rounded or lateral lobes. The animal is unknown, the cells are very small, unequal, completely immersed, obsoletely radiate and scattered; the polypidom is fixed, cellular within, finely porous and reticulated externally, extending into a palmated form.

Of the TUBULOUS MADREPORES, which consist almost entirely of fossil species chiefly belonging to the Silurian formation, we shall only note *Aulopora repens* as one of the best known species.

The RUGOSE MADREPORES.—Among these a highly developed sclerodermic skeleton occurs, each corallite being very distinct, and presenting, in many cases, both septa and tabulæ. Most Rugosa belong to the large family Cyathophyllidæ; and all of them are wholly extinct, extending from the Silurian to the Cretaceous period.

CORAL ISLANDS.

There is no spectacle in Nature more extraordinary or more worthy of our admiration than that now under consideration. These corals, whose history we have investigated—beings gifted with a half-latent life only—these animals so small and so fragile—labour silently and incessantly in the bosom of the ocean, and, as they exist in innumerable aggregated masses, their cells and solid axes produce in the end enormous stony masses. These calcareous deposits increase and multiply with such incalculable rapidity, that they not only cover the submarine rocks as with a carpet, but they finish by forming reefs, and even entire islands, which rise above the surface of the ocean in a manner remarkable at once for their form and the regularity with which they repeat themselves.

In noting the Indian and Pacific Oceans, navigators had long been

struck with the appearance of certain islands, which presented a conformation altogether singular. In 1601, Pyrard de Laval, speaking of the Malouine (now the Falkland) Islands, said:—"They are divided into thirteen provinces, named *atollons*, which is so far a natural division in that place, that each atollon is separated from the other, and contains a great number of smaller islands. It is a marvel to see each of these atollons surrounded on all sides by a great bank of stone—walls such as no human hands could build on the space of earth allotted to them. These atollons are almost round, or rather oval, being each about thirty leagues in circumference, some a little less, others a little more, and all ranging from north to south, without any one touching the other. There is between them sea channels, one broad, the other narrow. Being in the middle of an atollon, you see all around you this great stone bank, which surrounds and protects the island from the waves; but it is a formidable attempt, even for the boldest, to approach the bank and watch the waves as they roll in and break with fury upon the shore."

Since the publication of Laval's description, many circular isles, or groups of islands, analogous to these atollons, since called *atolls*, have been discovered in the Pacific Ocean and other seas. The naturalist Forster, who accompanied Cook in his voyage round the world, first made known the more remarkable characteristics of these wonderful formations. He perfectly comprehended their origin, which he was the first to attribute to the development of calcareous zoantharian polyps.

After Forster, many other naturalists—Lamouroux, Chamisso, Quoy, Gaimard, Ehrenberg, Ellis, Darwin, and Dana—have furnished science with many precious memoirs on the natural history of coral islands and coral reefs. We can only glance at a few of the more remarkable facts connected with these interesting formations.

The atolls present three unfailing and constant peculiarities. Sometimes they constitue a great circular chain, the centre of which is occupied by a deep basin, in direct communication with the exterior sea, through one or many breaches of great depth. These are the *atolls*, described more than two centuries ago by Pyrard de Laval; sometimes they surround, but at some distance, a small island, in such a manner as to constitute a sort of skeleton or girdle of reefs; finally they may form the immediate edging or border of an island or continent. In this last case they are called fringing reefs. At the distance of a few hundred yards only from the edge of some of these reefs, the sea is of such a depth that the sounding-lead has failed to reach the bottom.

In order to give an idea of the general form of these atolls, although they are rarely so regular, the reader is referred to PLATE IV., which represents one of these islands of the Pomotouan Archipelago, in the Indian Ocean. It represents the island of Clermont-Tonnerre, figured by Captain Wilkes in the American Exploring Expedition. The exterior girdle of rocks here surrounds a basin nearly circular. Such is the general form—the typical form, so to speak—of the coral islands, of which this is a fair representation.

The animals which form these immense accumulations belong to diverse groups, and nowhere have the results of observations made upon these atolls been more minutely described than in Mr. Darwin's remarks on the grand Cocos Island situated to the south of Sumatra, in the Indian Ocean.

No writer, it seems to us, has reasoned on these atolls more comprehensively than the author of the "Origin of Species." "The earlier voyagers," he says, "fancied that the coral-building animals instinctively built up their great corals to afford themselves protection in the inner parts; but so far is this from the truth, that those massive kinds, to whose growth on the exposed outer shores the very existence of the reef depends, cannot live within the lagoon, where other delicately-branching kinds flourish. Moreover, in this view, many species of distinct genera and families are supposed to combine for one end; and of such a combination not a single instance can be found in the whole of Nature. The theory that has been most generally received is, that atolls are based on submarine craters, but when the form and size of some of them are considered, this idea loses its plausible character. Thus, the Suadiva atoll is forty-four geographical miles in diameter in one line by thirty-four in another; Rimsky is fifty-four by twenty miles across; Bow atoll is thirty miles long, and, on an average, six miles broad. This theory, moreover, is totally inapplicable to the Northern Maldivian atolls in the Indian Ocean, one of which is eighty-eight miles in length, and between ten and twenty in breadth."

The various theories which had been propounded failing to explain the existence of the coral islands, Mr. Darwin was led to re-consider the whole subject. Numerous soundings taken all round the Cocos atoll showed that at ten fathoms the prepared tallow in the hollow of the sounding rod came up perfectly clean, and marked with the impression of living polyps. As the depth increased, these impressions became less numerous, but adhering particles of sand succeeded, until it was evident that the bottom consisted of smooth sand. From these observations, it was obvious to him that the

IV.—Coral Island of Clermont-Tonnerre, in the Pomotouan Archipelago.

utmost depth at which the coral polyps can construct reefs is between twenty and thirty fathoms. Now, there are enormous areas in the Indian Ocean in which every island is a coral formation raised to the height to which the waves can throw up fragments and the winds pile up sand; and the only theory which seems to account for all the circumstances embraced, is that of the subsidence of vast regions in this ocean. "As mountain after mountain and island after island slowly sank beneath the water," he says, "fresh bases would be successively afforded for the growth of the corals. I venture to defy any one to explain in any other manner how it is possible that numerous islands should be distributed throughout vast areas, all the islands being low, all built of coral absolutely requiring a foundation within a limited depth below the surface."

The *Porites*, according to Mr. Darwin, form the most elevated deposits of those which are situated nearer the level of the water: *Millepora complanata* also enters into the formation of the upper banks. Various other branched corals present themselves in great numbers in the cavities left by the *Porites* and *Millepora* crossing each other. It is difficult to identify living species when they live in the deeper parts, but, according to Darwin, the lower parts of the reefs are occupied by polyps of the same species as in the upper parts; at the depth of eighteen fathoms and upwards, the bottom consists alternately of sand and corals. The total breadth of the circular reef or ring which constitutes the atoll of the Keeling or Cocos Island varies from 200 to 500 yards in breadth. Some little parasitic isles form themselves upon the reefs, at 200 or 300 yards from their exterior edge, by the accumulation of the fragments thrown up here during great storms. They rise from two to three yards above the sea-level, and consist of dead shells, corals, and sea urchins, the whole consolidated into hard and solid rock.

The description of the Island of Cocos or Keeling is as follows:—"The ring-formed reef of the lagoon island is surmounted, in the greater part of its length, by linear islets. On the northern, or leeward side, there is an opening through which vessels can pass to the anchorage within. On entering, the scene was very curious, and rather pretty; its beauty, however, entirely depended on the brilliancy of the surrounding colours. The shallow, clear, and still water of the lagoon resting in its greater part on white sand, is, when illumined by a vertical sun, of the most vivid green. This brilliant expanse, several miles in width, is on all sides divided, either by a line of snow-white breakers from the dark heaving waters of the ocean, or from the blue vault of heaven by the strips of land crowned by the

level tops of the cocoa-nut tree. As a white cloud here and there affords a pleasing contrast to the azure sky, so in the lagoon, bands of living coral darken the emerald-green water.

"The next morning I went ashore on Direction Island. The strip of dry land is only a few hundred yards in width; on the lagoon side there was a white calcareous beach, the radiation from which, under this sultry climate, was very oppressive. On the outer coast, a solid broad flat of coral rock served to break the violence of the open sea. Excepting near the lagoon, where there is some sand, the land is entirely composed of rounded fragments of coral. In such a loose, dry, stony soil, the climate of the intertropical regions alone could produce so vigorous a vegetation. On some of the smaller islets nothing could be more elegant than the manner in which the young and full-grown cocoa-nut trees, without destroying each other's symmetry, were mingled into one wood. A beach of glittering white sand formed a border to those fairy spots.

"The natural history of these islands, from its very paucity, possesses peculiar interest. The cocoa-nut tree, at the first glance seems to compose the whole wood; there are, however, five or six other trees. One of these grows to a very large size, but, from the extreme softness of its wood, it is useless; another sort affords excellent timber for ship-building. Besides the trees, the number of plants is exceedingly limited, and consist of insignificant weeds. In my collection, which includes, I believe, nearly the perfect Flora, there are twenty species, without reckoning a moss, lichen, and fungus. To this number two trees must be added, one of which was not in flower, and the other I only heard of. The latter is a solitary tree of its kind, and grows near the beach, where, without doubt, the one seed was thrown up by the waves.

"The next day I employed myself in examining the very interesting yet simple structure and origin of these islands. The water being unusually smooth, I waded over the flat of dead rock as far as the living mounds of coral, on which the swell of the open sea breaks. In some of the gulleys and hollows there were beautiful green and other coloured fishes, and the forms and tints of many of the zoophytes were admirable. It is excusable to grow enthusiastic over the infinite number of organic beings with which the sea of the Tropics, so prodigal of life, teems; yet I must confess, I think those naturalists who have described in well-known words the submarine grottoes decked with a thousand beauties, have indulged in rather exuberant language.

"I accompanied Captain Fitzroy to an island at the head of the lagoon; the channel was exceedingly intricate, winding through field

f delicately-branched corals. At the head of the lagoon we crossed a arrow islet, and found a great surf breaking on the windward coast. can hardly explain the reason, but there is, to my mind, much andeur in the view of the outer shores of these lagoon islands. here is a simplicity in the barrier-like beach, the margin of green ushes and tall cocoa-nuts, the solid flat of dead coral-rock, strewed ere and there with great loose fragments, and the line of furious reakers, all rounding away towards either hand. The ocean, throwg its waters over the broad reef, appears an invincible, all-powerful nemy; yet we see it resisted and even conquered by means which at rst seem most weak and insufficient. It is not that the ocean spares e rock of coral; the great fragments scattered over the reef, and eaped on the beach whence the tall cocoa-nut trees spring, plainly espeak the unrelenting power of the waves. Nor are any periods of pose granted; the long swell caused by the gentle but steady action f the trade-winds, always blowing in one direction over a wide area, uses breakers almost equalling in force those during a gale of wind the temperate regions, and which never cease to rage. It is imossible to behold these waves without feeling a conviction that an land, though built of the hardest rocks—let it be porphyry, granite, r quartz—would ultimately yield and be demolished by such an resistible power. Yet these low, insignificant coral islets stand, and re victorious; for here another power, as an antagonist, takes part the contest. The organic forces separate the atoms of carbonate f lime, one by one, from the foaming breakers, and unite them into symmetrical structure. Let the hurricane tear up its thousand huge agments, yet what will that tell against the accumulated labour of yriads of architects at work night and day, month after month? hus do we see the soft and gelatinous body of a polyp, through the gency of the vital laws, conquering the great mechanical power of e waves of an ocean which neither the art of man nor the inanimate orks of Nature could successfully resist."

We have said that these coral formations are of three forms, to hich the names of *atolls*, *barrier reefs*, and *fringing reefs*, have been plied. We have spoken of atolls; we shall now say a few words barrier and fringing reefs.

The *barrier reefs* are formations which surround the ordinary lands, or stretch along their banks. They have the form and neral structure of atolls. Like atolls, the barrier reefs appear aced on the edge of a marine precipice. They rise on the edge of plateau which looks down on a bottomless sea. On the coast of

New Caledonia, only two lengths of his ship from the reef, Captain Kent found no bottom in 150 fathoms. This was verified at Gambier Island in the Pacific Ocean, in Qualem Island, and at many others.

According to Mr. Darwin, the barrier reef situated on the western coast of New Caledonia is 400 miles long; that along the eastern coast of Australia extends almost without interruption for 1,000 miles, ranging from twenty or thirty to fifty or sixty miles from the coast. As to the elevation of the islands thus surrounded with reefs, it varies considerably. The Isle of Tahiti rises 6,800 feet above the level of the sea; the Isle of Maurua to 600; Aituaki to 300; and Manonai to about fifty feet only.

Around the Isle of Gambier the reef has a thickness of 1,060 feet, at Tahiti of 230. Round the Fiji Islands it is from 2,000 to 3,000.

The *fringing reefs* immediately surrounding the island, or a portion of it, might be confounded with the barrier reefs we have been describing, if they only differed in their smaller breadth; but the circumstance that they abut immediately on the coast in place of being separated by a channel or lagoon more or less deep and continuous, proves that they are in direct communication with the slope of the submarine soil, and permits of their being distinguished from the barrier reefs. The dangerous breakers which surround the Mauritius are a striking example of the fringing reef. This island is almost entirely surrounded by a barrier of these rocks, the breadth of which varies from 150 to 330 feet; their rugged and abrupt surface is worn almost smooth, and is rarely uncovered at low water. Analogous reefs surround the Isle of Bourbon; all round this island the polyps construct on the volcanic bottom of the sea detached masses, which rise from a fathom to a fathom and a half above the water.

Coral coasting reefs present themselves also on the eastern coast of Africa and of Brazil. In the Red Sea, reefs of corals exist which may be ranked among the coasting reefs, in consequence of the limited breadth of the gulf. Ehrenberg and Hemprich examined 150 stations in the Red Sea, all of which had outlying fringing reefs of this description.

It may be asked, With what rapidity are these coral banks formed, so as to become *atolls* and *fringing reefs?* To answer this question even approximately is very difficult. On the coast of the Mauritius, according to M. d'Archiac,* one of the learned professors

* "Cours de Paléontologie Stratigraphique."

of the Jardin des Plantes, the edge of the reef is produced by *Madrepora corymbosa*, *M. pocillifera*, and two species of *Astrea*, which pursue their operations at the depth of from eight to fifteen fathoms. At the base is a bank of *Seriatopora*, from fifteen to twenty fathoms in height. At the bottom, the sand is covered with *Seriatopora*. At twenty fathoms we also meet with fragments of *Madrepora*. Between twenty and forty fathoms the bottom is sandy, and the sounding-rod brings up great fragments of *Caryophyllia*. According to MM. Quoy and Gaimard, the species of *Astrea*, which, as these naturalists consider, constitute the greater part of the reefs, cannot live beyond four or five fathoms deep. *Millepora alcicornis* extends from the surface to the depth of twelve fathoms; the *Madrepores* and *Seriatopores* down to twenty fathoms. Considerable masses of *Meandrina* have been observed at sixteen fathoms; and a *Caryophyllia* has been brought up from eighty fathoms in thirty-three degrees south latitude. Among the polyps which do not form solid reefs, Mr. Darwin mentions *Gorgonia* at 160, *Corallines* at 100, *Millepora* at from thirty to forty-five, *Sertularians* at forty, and *Tubulipora* at ninety-five fathoms.

According to Dana, none of the species of the genera which form reefs—namely, *Madrepora*, *Millepora*, *Porites*, *Astrea*, and *Meandrina*—can live at a greater depth than eighteen fathoms. It is only near the surface of the water that the zoantharia which produce polypidoms and form coral banks put forth their powers; the points most exposed to the beating of the waves is that which is most favourable to their growth; it is there that the finest specimens of the genera *Astrea*, *Porites*, and *Millepora* most abound.

The proportionate increase of the structures, according to Mr. Darwin, depends at once upon the species which construct the reefs and upon various accessory circumstances. The ordinary rate of increase of the madrepores, according to Dana, is about an inch and a half annually; and, as their branches are much scattered, this will not exceed half an inch in thickness of the whole surface covered by the madrepore. Again, in consequence of their porosity, this quantity will be reduced to three-eighths of an inch of compact matter. The sands, too, filling up the destroyed part of the polyp are washed out by the currents in the great depths where there are no living corals, and the surface occupied by them is reduced to a sixth of the whole coralline region, which reduces the preceding three-eighths to one sixth. The shells and other organic débris will probably represent a fourth of the total produce in relation to corals. In this manner, taking everything into account, the mean increase of a reef cannot

exceed the eighth of an inch annually. According to this calculation, some reefs which are not less than 2,000 feet thick would require for their formation 192,000 years.

It is necessary, however, to add that in favourable circumstances the increase of the masses of coral may be much more rapid. Mr. Darwin speaks of a ship which, having been wrecked in the Persian Gulf, was found, after being submerged only twenty months, to be covered with a bed of coral two feet in thickness; he also mentions experiments made by Mr. Allen on the coast of Madagascar, which tend to prove that in the space of six months certain corals increased nearly three feet.

We proceed to the theoretic explanation of these curious organic formations.

Naturalists and navigators have been much divided in opinion as to the true origin of these coral islands. Most of them have admitted that these enormous banks are composed of the calcareous remains and earthy detritus of the madrepores and corals, which, developing themselves in their midst, or upon the bed of the ocean, multiplying and superposing themselves, age after age, and generation after generation, have finally concluded by forming deposits of this immense extent. The growth of the vast madreporic mass would be finally arrested by the want of water when its summit approached the level of the sea. It is thus that Forster, Péron, Flinders, and Chamisso, have explained the formation of the *atolls* and *fringing reefs*. This opinion has also found a supporter in our times in the French Admiral Du Petit Thouars. But he objects, with reason, that the corals cannot live at the prodigious depth of sea at which the base of these islets lie. It has therefore been found necessary to seek for another cause to satisfy the diverse conditions of the phenomena, and explain, at the same time, the strange circular arrangement of these islands, which is almost constant, and which it is essential to keep in view.

Sir Charles Lyell was of opinion that the base of an atoll was always the crater of an ancient submarine volcano, which, when crowned with corals and madrepores, would naturally reproduce this circular wall-like shape formed of heaped-up corals.

This theory supposes the existence of volcanic craters in the neighbourhood of all the coral islands. It is quite certain that these islands are often found not far from extinct volcanoes; and Sir Charles Lyell has published a very curious map in connection with the subject; nevertheless, the coincidence does not always exist. We have already remarked on the theory by which Mr. Darwin seeks to explain

the complicated conditions of the phenomena. The explanation proposed accounts for the known facts, as well as the present appearance of the madreporic islands. The circular atolls and fringing reefs which are disposed as a sort of girdle, are principally formed of species of the genera *Porites*, *Millepora*, *Astrea*, zoantharia which cannot exist at any great depth in the ocean, but which swarm on the rocks at some few fathoms only below the limits of the tide. These animals, by means of their accumulated débris, soon form a sort of coating round the island, which constitutes the littoral reefs; this marginal shoulder, according to Mr. Darwin, is the first stage in the existence of a coral island. At this point the author introduces a geological cause, namely, a great subsiding movement of the soil, in which the madreporic colony is sunk under the water. It is evident that after submersion the coral will only continue to develop itself on the upper surface, and within the limits which its nature prescribes. The madrepores exhibiting their greatest vitality at the points most exposed to the fury of the waves, it will be near the outer edge of the reef that their development will be most rapid. If the subsidence of the island thus surrounded should still continue, as mountain after mountain and island after island slowly sink beneath the water, fresh bases would be successively afforded for the growth of the corals, and the outer edge elevated by their continual labour, thus transforming the space into a sort of circular lagune. The coral deposits would thus form an isolated girdle, and the lagune, which occupies the centre, would become deeper and deeper in proportion to the lowering of the soil. This is the second stage of the coral isle.

The existence of the atolls are thus subordinated to two principal conditions—the progressive subsidence of the shore washed by the sea, and the existence of coral formed of a hard stony substance, the growth and multiplication of which was extremely rapid.

It follows from this that coral isles cannot exist in all seas; that they can only have their birth in the torrid zone, or at least near the tropics, for it is only in these regions where the warmth exists, so necessary to their development, that the madrepores show themselves in greatest abundance.

The great field of coral formations, in short, is found in the warm parts of the Indian and Pacific Oceans. It is from these oceans, as from common centres, round which are ranged the series of coral isles and islets, that it will be useful, in concluding this chapter, to trace their geographical distribution. We borrow the materials for this from Milne-Edwards's table of their distribution in the principal seas of the world.

It is, as we have said, only in the warm parts of the Indian and Pacific Oceans that the great mass of these islands are found. They give birth towards the south to the group of atolls known as the archipelago of the Bashee Islands, the extreme limit of the region being the Isle of Ducie. A multitude of other islands of the same nature are sparsely scattered over the sea, up to the east coast of Australia. There are enormous areas here, in which every single island is of coral formation, and is raised to the height at which the waves can throw up fragments. The Radack group is a quadrilateral, 400 miles long by 240 broad. Between this group and the Low Archipelago itself, 840 miles by 420, there are groups and single islands covering a linear space of more than 4,000 miles. To the north of the Equator, the archipelago of the Caroline Islands constitutes a very considerable group of coral islands, comprehending upwards of 1,000, extending in a broad belt over nearly 40° of longitude. On the other hand, all along the coast of the American continent, round the Galapagos and the Isle of Paques, we find no trace of them. The reason assigned is, that in these regions a great current of cold water, flowing from the Antarctic Pole, so much lowers the temperature of the sea, that the corals can no longer exist.

We still meet with atolls in the Chinese Seas, and coral barrier reefs are abundant round the Marianne and Philippine Islands. These marginal reefs form also an immense tract, from the Isle of Timor, along the south coast of Sumatra, up to the Island of Nicobar, in the Bay of Bengal.

To the west of the Indian Peninsula, the Maldive and Laccadive Islands form the extremity of another group of atolls, and important madreporic reefs, which extend towards the south, by the Maldives and the Chagos Islands; they consist of low coral formations, densely clothed with cocoa-nut trees. The Maldives, the most southerly cluster, include upwards of 1,000 islands and reefs; the Laccadives, seventeen in number, are of similar origin. The Saya de Malha Bank, towards the south-east, constitutes a further group of madreporic islets. Finally, the coast of the Mauritius, of Madagascar, of the Seychelles, and even the African continent, from the northern extremity of the Mozambique Channel to the bottom of the Red Sea, are studded with numerous reefs of the same nature. They fail, however, almost completely, along the coast of the Asiatic continent, where, among others, the waters of the Euphrates, the Indus, and the Ganges, enter the sea. The western coast of Africa, and the east coast of the American continent, are almost entirely destitute of great madreporic reefs, but they abound in the Caribbean Seas. In the Gulf of Mexico,

where the vast freshwater current of the Mississippi debouches into the sea, they are unknown. It is principally on the north coast and upon the eastern flanks of the chain of West Indian Islands that the coral reefs show themselves in these regions.

The Actinidæ.

Here we leave the group of polyps which form united families. The Sea Anemones, of which the genus *Actinia* is the type, consist of *Zoantharia*, which produce no true polypidom, that is to say, of polyps whose integument remains always soft, and in whose interior no calcareous plates are produced. This order is usually divided into two groups—that in which the base is adherent at pleasure, as in *Actinia*, and that in which the base is not adherent, as in *Ilyanthus*.

The modern aquarium enables the spectator to witness many wonderful sights. Adherent against the transparent crystal walls of the basin, he observes living creatures of the most brilliant shades of colour, and more resembling flowers than animals. Supported by a base and cylindrical stem, he sees them terminate like the corolla of a flower, as in the petals of the anemone: these are the animals we call *Sea Anemones*—curious creatures, which, as all persons familiar with the sea-shore may have observed, are at one time seen suspended from the rocks, and again buried at the bottom of the sea. These charming and timid creatures are also called *Actinia*, as indicating their disposition to form rays or stars, from the Greek ἀκτὶς, a ray.

The body of these animals is cylindrical in form, terminating beneath in a muscular disc, which is generally large and distinct, enabling them to cling vigorously to foreign bodies. It terminates above in an upper disc, bearing many rows of tentacles, which differ from each other only in their size. These tentacles are sometimes decorated with brilliant colours, forming a species of collar, consisting of contractile and often retractile tubes, pierced at their points with an orifice, whence issue jets of water, which are ejected at the will of the animal. Arranged in circles, they are distributed with perfect regularity round a central mouth. These are their arms.

The mouth of the Sea Anemone opens among the tentacles. Oval in form, it communicates by means of a short tube with a stomach, broad and short, which descends vertically, and abuts by a large opening on the visceral cavity, the interior of which is divided into little chambers. These chambers are not all of the same dimensions; in parting from the cylindrical walls of the body, they advance,

the one increasing, the others getting smaller, in the direction of the centre. Moreover, they have many kinds of cells, which dispose themselves in their different relations with great regularity—their tentacula, which correspond with them, being arranged in circles radiating more or less from the centre.

The stomach of the sea anemones fulfils a multitude of functions. At first, it is the digestive organ, and is unceasingly moistened by the water which it passes through it, takes what nourishment is in it, and ejects. The general cavity of the body corresponds with the visceral cavity, but is separated from it by a thin partition, and in the general cavity, which is divided into compartments by perpendicular partitions of membrane, the reproductive organs, the eggs, and the young, are lodged, and are all connected with the tentacles or arms. In the month of September the eggs are fecundated, and the larva or embryos developed. As Frédol says in "La Monde de la Mer," "These animals bear their young, not upon their arms, but *in* their arms. The larva generally pass from the tentacula (*i.e.*, from the general cavity) into the stomach, and are afterwards ejected from the mouth along with the rejecta of their food, a most singular fact—the mouth serving the purposes of accouchement—a fact which it would be difficult to believe on other than the most positive evidence."

"The Daisy-like Anemone (*Sagartia bellis*, Gosse), in the Zoological Gardens of Paris," says Frédol, "frequently throws up young ones, which are dispersed, and attach themselves to various parts of the aquarium, and finally become miniature anemones exactly like the parent. An actinia which had taken a very copious repast ejected a portion of it about twenty-four hours later, and in the middle of the ejected food were found thirty-eight young individuals." According to Dalyell, an accouchement is here a fit of indigestion.

The lower class of animals have, in fact, as the general basis of their organisation, a sac with a single opening, which is applied, as we have seen, to a great variety of uses. It receives and rejects; it swallows and it vomits. The vomiting becomes necessary and habitual—the normal condition, in short, of the animal—and is perhaps a source of pleasure to it, for it is not a malady, but a function.

The sea anemones are also developed in another manner. On the edge of their base certain bud-like excrescences may often be observed. These buds are by-and-by transformed into embryos, which detach themselves from the parent form, and soon become individuals in all respects resembling it. This mode of reproduction greatly resembles some of the vegetative processes. Another and very singular mode of reproduction has been noted by Mr. Hogg in the

case of *Actinia œillet.* Wishing to detach this anemone from the aquarium, this gentleman used every effort to effect his purpose; but only succeeded, after violent exertions, in tearing the lower part of the animal. Six portions remained attached to the glass walls of the aquarium. At the end of eight days, attempts were again made to detach these fragments; but it was observed, with much surprise, that they shrank from the touch, and contracted themselves. Each of them soon became crowned with a little row of tentacula, and finally each fragment became a new anemone. Every part of these strange creatures thus becomes a separate being when detached, while the mutilated parent continues to live as if nothing had happened. It has long been known that the sea anemones may be cut limb from limb, mutilated, divided, and subdivided. One part of the body cut off is quickly replaced. Cut off the tentacles of an actinia, and they are replaced in a short time, and the experiment may be repeated indefinitely. The experiments made by M. Trembley of Geneva upon the fresh-water hydra were repeated by the Abbé Dicquemare on the sea anemones. He mutilated and tormented them in a hundred ways. The parts cut off continued to live, and the mutilated creature had the power of reproducing the parts of which it had been deprived. To those who accused the abbé of cruelty in thus torturing the poor creatures, he replied that, so far from being a cause of suffering to them, "he had increased their term of life, and renewed their youth."

The *Actiniadæ* vary in their habitat from pools near low-water mark to eighteen or twenty fathoms water, whence they have been dredged up. "They adhere," says Dr. Johnston, "to rocks, shells, and other extraneous bodies by means of a glutinous secretion from their enlarged base, but they can leave their hold and remove to another station whensoever it pleases them, either by gliding along with a slow and almost imperceptible movement (half an inch in five minutes), as is their usual method, or by reversing the body and using the tentacula for the purpose of feet, as Réaumur asserts, and as I have once witnessed; or, lastly, inflating the body with water, so as to render it more buoyant, they detach themselves, and are driven to a distance by the random motion of the waves. They feed on shrimps, small crabs, whelks, and on very many species of shelled mollusca, and probably on all animals brought within their reach whose strength or agility is insufficient to extricate them from the grasp of their numerous tentacula; for as these organs can be turned about in any direction, and greatly lengthened, they are capable of being applied to every point, and adhere by suction with considerable

tenacity, throwing out (according to Gaertner) of their whole surface a number of extremely minute suckers, which, sticking fast to the small protuberances of the skin, produce the sensation of roughness, which is so far from being painful that it even cannot be called disagreeable.

The size of the prey is frequently in unseemly disproportion to the preyer, being often equal in bulk to itself. I had once brought me a specimen of *Actinia crassicornis*, that might have been originally two inches in diameter, which had somehow contrived to swallow a valve of *Pecten maximus* of the size of an ordinary saucer. The shell, fixed within the stomach, was so placed as to divide it completely into two halves, so that the body, stretched tensely over, had become thin and flattened like a pancake. All communication between the inferior portion of the stomach and the mouth was of course prevented; yet, instead of emaciating and dying of atrophy, the animal had availed itself of what undoubtedly had been a very untoward accident to increase its enjoyment and its chance of double fare. A new mouth, furnished with two rows of numerous tentacula, was opened up on what had been the base, and led to the under stomach; the individual had indeed become a sort of Siamese Twin, but with greater intimacy and extent in its unions!"

The sea anemones pass nearly all their life fixed to some rock, to which they seem to take root. There they live a sort of unconscious and obtuse existence, gifted with an instinct so obscure that they are not even conscious of the prey in their vicinity until it is actually in contact, when it seizes it in its mouth and swallows it. Nevertheless, though habitually adherent, they can move, gliding and creeping slowly by successive contractile and relaxing movements of the body, extending one edge of their base and relaxing the opposite one.

At the approach of cold weather the *Actinia* are said to descend into the deepest water, where they find a more agreeable temperature.

We have said that the sea anemones are scarcely possessed of vital instinct; but they are capable of certain voluntary movements. Under the influence of light, they expand their tentacles as the daisy displays its florets. If the animal is touched, or the water is agitated in its neighbourhood, the tentacles close immediately. These tentacles appear occasionally to serve the purpose of offensive arms. The hand of the man who has touched them becomes red and inflamed. M. Hollard has seen small mackerel, two to three inches long, perish when touched by the tentacles of the Green Actinia (*Corynactis viridis*, Allman). This is a charming little animal.

"The brilliancy of its colours and the great elegance of its tentacular crown when fully expanded," says Professor Allman, "render it eminently attractive; hundreds may often be seen in a single pool, and few sights will be remembered with greater pleasure by the naturalist than that presented by these little zoophytes, as they expand their green and rosy crowns amid the algæ, millepores, and plumy corals, co-tenants of their rock-covered vase!"

The toxicological properties of the Actinia have been attributed to certain special cells full of liquid; but M. Hollard believes that these effects are neither constant enough nor sufficiently general to constitute the chief function of these organs, which are found in all the species and over their whole surface, external and internal. Though quite incapable of discerning their prey at a distance, the sea anemone seizes it with avidity when it comes to offer itself up a victim. If some adventurous little worm, or some young and sluggish crustacean, happens to ruffle the expanded involucrum of an actinia in its lazy progress through the water, the animal strikes it at once with its tentacles, and instinctively sweeps it into its open mouth. This habit may be observed in any aquarium, and is a favourite spectacle at the "Jardin d'Acclimatation" of Paris, at noon on Sundays and Wednesdays, when the aquatic animals are fed. Small morsels of food are thrown into the water. Prawns, shrimps, and other crustaceans and zoophytes inhabiting this medium, chase the morsels as they sink to the bottom of the basin; but it is otherwise with the Actinia; the morsels glide downward within the twentieth part of an inch of their crown without their presence being suspected. It requires the aid of a directing wand, directed by the hand of the keeper, to guide the food right down on the animal. Then its arms or tentacles seize upon the prey, and its repast commences forthwith.

The Actinia are at once gluttonous and voracious. They seize their food with the help of their tentacula, and engulf in their stomach, as we have seen, substances of a volume and consistence which contrast strangely with their dimensions and softness. In less than an hour, M. Hollard observed that one of these creatures voided the shell of a mussel, and disposed of a crab all to its hardest parts; nor was it slow to reject these hard parts, by turning its stomach inside out, as one might turn out one's pocket, in order to empty it of its contents. We have seen in Dr. Johnston's account of *A. crassicornis*, that when threatened with death by hunger, from having swallowed a shell which separated it into two halves, at the end of eleven days it had opened a new mouth, provided with separate rows of tentacula. The accident which, in ordinary animals, would have

left it to perish of hunger, became, in the sea anemone, the source of redoubled gastronomical enjoyment.

"The anemones," Frédol tells us, "are voracious, and full of energy; nothing escapes their gluttony; every creature which approaches them is seized, engulfed, and devoured. Nevertheless, with all the power of their mouth, their insatiable stomachs cannot retain the prey they have swallowed. In certain circumstances it contrives to escape, in others it is adroitly snatched away by some neighbouring marauder more cunning and more active than the anemone.

"It is sometimes observed in aquariums that a shrimp, which has seen the prey devoured from a distance, will throw itself upon the ravisher, and audaciously wrest the prey from him and devour it before his eyes, to his great disappointment. Even when the savoury morsel has been swallowed, the shrimp, by great exertions, succeeds in extracting it from the anemone's stomach. Seating itself upon the extended disc of the anemone, with its small feet it prevents the approach of the tentacles, at the same time that it inserts its claws into the digestive cavity and seizes the food. In vain the anemone tries to contract its gills and close its mouth. Sometimes the conflict between the sedentary zoophyte and the vagrant crustacean becomes serious. When the former is strong and robust, the aggression is repelled, and the shrimp runs the risk of supplementing the repast of the anemone."

If the actinias are voracious, they can also support a prolonged period of fasting. They have been known to live two and even three years without having received any nourishment."*

Although the sea anemone is said to be delicate eating, man derives very little benefit from them in that respect. In Provence, Italy, and Greece, the Green Actinia is in great repute; and Dicquemare speaks of *A. crassicornis* as delicate food. "Of all the kinds of sea anemones, I would prefer this for the table; being boiled some time in sea water, they acquire a firm and palatable consistence, and may then be eaten with any kind of sauce. They are of an inviting appearance, of a light shivering texture, and of a soft white and reddish hue. Their smell is not unlike that of a warm crab or lobster." Dr. Johnston admits the tempting description, and does not doubt their being not less a luxury than the sea urchins of the Greeks, or the snails of the Roman epicures, but he was not induced

* "On en a vu vivre deux et même trois ans, sans recevoir de nourriture."—*Vie des Animaux*, p. 117.

V.—Sea Anemones.

to test its truth. Rondeletius tells us, having, as Dr. Johnston thinks, *A. crassicornis* in view, that it brings a good price at Bordeaux. *Actinia dianthus* also is good to eat, quoth Dicquemare, and Plaucus directs the cook to dress it after the manner of dressing oysters, with which it is frequently eaten. *Actinia coriacea* is found in the market at Rochefort during the months of January, February, and March. Its flesh is said to be both delicate and savoury.

With these general considerations, we proceed to note some of the more remarkable genera and species of these interesting creatures. Among these, the species represented in PLATE V. are the ones usually seen collected in such aquariums as those of the Zoological Gardens of London and Dublin and the Garden of Acclimatisation of Paris.

The first section of the group of *Actiniadæ*, in which the base is adherent at pleasure, includes, according to Mr. Gosse, those anemones in which the tentacles are compound. To this section belongs, among others, the genus *Metridium*. A second section contains those where the tentacles are simple. Here we find the pretty *Corynactis viridis*.

C. viridis has very numerous tentacula, sometimes as many as 100, exceeding in length the breadth of the body, of a fine brownish or olive green, and rose-coloured at the extremity. The trunk is of a greyish green or brown; the disc is brown with greenish rays. This species is plentiful in the Mediterranean and on the south-east coasts of Great Britain and Ireland. When attached to the vertical sides of a rock, a little below the surface of the water, in which position it is often seen, the tentacles hang suspended, as if the animal had no power to display them in their radiate form; but when fixed horizontally in a calm sea, they are spread out in all directions, and are kept in a state of continual agitation; its long, handsome tentacula, fully expanded, float and balance themselves in the water in spite of the action of the waves, presenting a most interesting spectacle as it displays its beauties a few feet below the surface of the water.

Actinoloba dianthus (Ellis) is represented in PLATE VI., Fig. 1; its body is smooth and cylindrical; the disc marked in the centre with clavate radiating bands; tentacula numerous, irregular, the outer small, and forming round the margin a thick filamentous fringe. This species attaches itself to rocks and shells in deep water, or within low-water mark, to which it permanently attaches itself, and can scarcely be removed without organic injury to the base. When contracted, the body presents a thick, short, sub-cylindrical form,

about three inches long, and one and a half in diameter, and about five inches when fully expanded; the skin is smooth, of a uniform olive, whitish, cream, or flesh colour. The centre of the disc is ornamented with a circle of white bands, radiating from the mouth, the lamellæ running across the circumference being perceptible through the transparent skin. From the narrow colourless interspaces between the lamellæ the tentacula originate. "They are placed," says Dr. Johnston, "between the mouth and the margin, which is encircled by a dense fringe of incontestable beauty, composed of innumerable short tentacula or filaments, forming a thick, furry border." In PLATE V., Figs. 9, 10, we have probably *Anthea cereus* (Ellis), the body of which is a light chestnut colour, smooth, sulcated lengthwise, with tentacula rising from the disc to the number, in aged animals, of 200. *Sagartia viduata*, Gosse (PLATE VI., Fig. 4), has the body adherent, cylindrical, destitute of warts, emitting capsuliferous filaments from pores; nettling-threads short, densely armed with a brush of hairs; tentacles above 200 arranged in five rows. *A. picta*, which Professor Edward Forbes changed to *Adamsia palliata*, is described by Mr. Adams, who first discovered it, "as longitudinally sulcated, having the edges of the base crenated; the lower part an obscure red, and the upper part transparent white, marked with fine purple spots; the outer circumference of the aperture has a narrow stripe of pink. When expanded, the superior division of the body seems formed of membrane. From perforated warts placed without order on the outer coat, issued white filamentous substances variously twisted together. I have observed," he adds, "similar bodies ejected from the mouths of all the species of this genus which have fallen within my notice." This species is generally found adherent to the mouth of turbinate shells of Gasteropods, which it sometimes invests with a horny membrane.

Actinia mesembryanthemum (Johnston). This species is extremely common on rocks between the tide marks all round the coasts of Great Britain and Ireland, as well as those of France. It attaches itself chiefly to rocks beaten by the waves and exposed to view at the time of low water. The body is from two to three inches in height, and from an inch to an inch and a half in diameter; hemispherical when contracted, it resembles a bell perforated at the summit, dilated into a cylinder. When fully extended the tentacula are nearly equal to the height of the body, of a uniform liver colour, or olive green, and sometimes streaked with blue, having a greenish line either continuous or in spots, the base generally of a greenish

VI.—Sea Anemones.

colour encircled with an azure blue line, often streaked with red. The tentacula are terminated by a small pore. Its colour is variable, but generally it is of a violet-red. Sometimes it presents round spots of a fine green; at other times it is only of a greenish hue; the edge of the feet have a narrow border of red, with green and blue beneath.

The verrucous or warty section of the *Actiniadæ* have the lateral walls of the column covered with warts. To this section belong the Dahlia Wartlet, *Tealia crassicornis* (Johnston), with its many varieties. Hollard describes them as frequently buried in the sands on the shore; while Mr. Cocks describes them "as attaching themselves to

Fig. 74.—Edwardsia calimorpha (Gosse).

shells and stones in deep water, or attached on the littoral to the sides of rocks, in crevices, or on the face of clean stones in sheltered places." The body is variegated, green, and red; the tentacles thick, short, and greyish, with broad roseate bands.

Coming now to the section where the base is not adherent, we find anemones with the base small, and terminating in a rounded point, and the body much elongated, as in *Edwardsia calimorpha* (Fig. 74), in which the body is non-adherent, somewhat worm-like, having the mouth and tentacula seated on a retractile column, the lower extremity inflated, membranous, and retractile.

Milne-Edwards also forms a special group of the genus *Phyllactis*. In this group the polyps are simple, fleshy, and present at once simple and composite tentacula. Such is *Phyllactis prætexta* (Fig. 75), which is found in the neighbourhood of Rio Janeiro. The anemone

fixes itself upon the rocks on the sea-shore, and covers itself with sand. Its trunk, of cylindrical form, is of a flesh-colour, with vertical lines, having red points. The interior tentacles form two simple elongated rows; the exterior tentacles are spatulate and lobed, not very unlike the leaves of the oak.

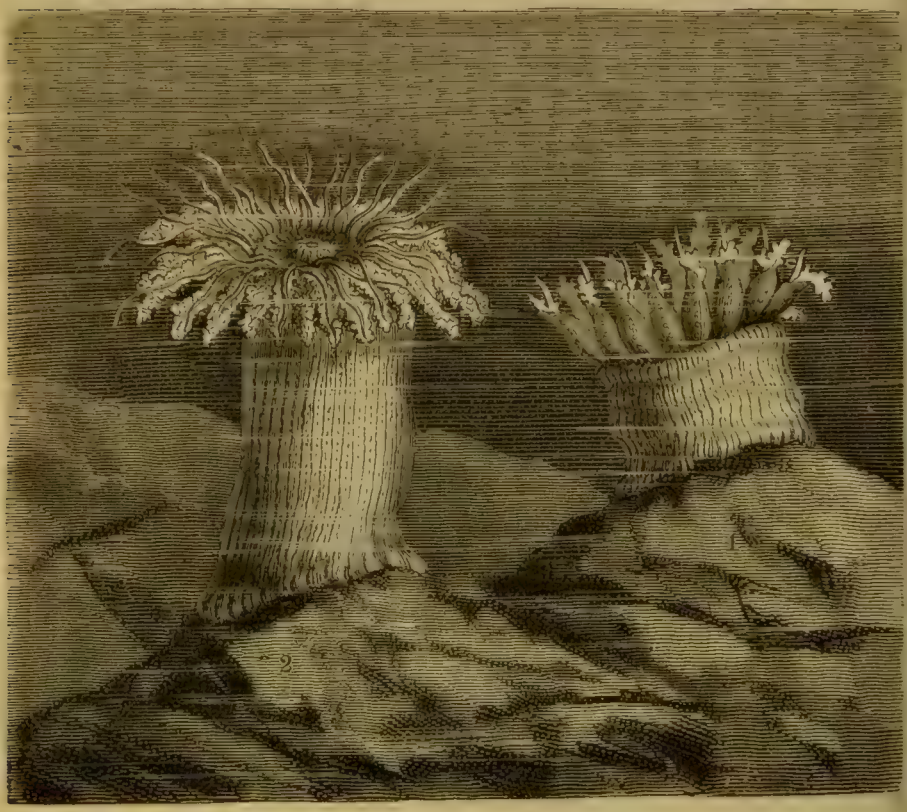


Fig. 75.—Phyllactis prætexta (Dana), natural-size.

The sub-family Thalassianthinæ is distinguished from the preceding by having all its tentacula short, pinnate, and branching, or papilliferous. One species only is known, *Thalassianthus aster*, of a slate colour, which inhabits the Red Sea.

The sub-family Minyadinæ seem to represent among the Zoantharia the Pennatula among the Alcyonaria. In the case of these animals, the base of the body, in place of extending itself in a

disc-like form, in order to grapple with the rock and other projections at the bottom of the sea, turns itself inwards, forming a sort of purse, which seems to imprison the air. From this results a sort of hydrostatic apparatus, aided by which the animals can float in the water and transport themselves from one place to another. The Blue Minyad (*Minyas cyanea*, Fig. 76) will serve as a type of this family;

Fig. 76.—Blue Minyad, *Minyas cyanea* (Cuvier), natural size.

its globose, melon-like form is of azure blue, studded with white wart-like excrescences; it is flattened at its two extremities in its state of contraction, and it has three rows of tentacula, which are short, cylindrical, and white. The internal organs are of a delicate rose colour. Cuvier placed this species among the Echinodermata, but the observations of Lesueur and Quoy, who were acquainted with the living animal, at once showed that its true place was among the free-swimming Actiniadæ. Many of the species, which are usually fixed, are still capable of swimming and of inflating their suctorial discs; therefore it is by no means as yet quite certain that the free habit of *Minyas cyanea* is constant.

CHAPTER VIII.

ALCYONARIA.

"As for your pretty little seed-cups, or vases, they are a sweet confirmation of the pleasure Nature seems to take in superadding elegance of form to most of her works. How poor and bungling are all the imitations of art! When I have the pleasure of seeing you next, we shall sit down—nay, kneel down—and admire these things."—HOGARTH TO ELLIS.

THE Alcyonaria are so designated from their principal type, that of Alcyonium. The species are all marine. The Alcyonaria may be defined as Actinozoa in which each polype is furnished with eight pinnately fringed tentacles. The chambers into which the body is divided are some multiple of four. The corallum is often dense, sometimes consisting, however, of calcareous spicules, and unlike that in the Zoantharia, never showing traces of septa. We shall see, farther on, that among the Gorgonidæ the coral ceases to be spongy and cellular; that its axis assumes a horny consistence, which becomes often even stony; but the external barky layer, which is the special lodging of the polyps, always remains soft on the surface. We shall have a general idea of the organisation, habit, and mode of multiplication among the Alcyonaria when we come to treat of the precious coral and its strange history. The class Alcyonaria may be divided into many orders. We shall consider—I. The *Tubiporidæ*. II. The *Gorgonidæ*. III. The *Pennatulidæ*. IV. The *Alcyonidæ*.

I. THE TUBIPORIDÆ

form a group consisting of several species, which live in the bosom of tropical seas, in which the Coral Islands form so prominent a a feature. The group is exclusively formed of the curious genus *Tubipora*.

The *Tubipora* is a calcareous coral, formed by a combination of distinct, regularly-arranged tubes, connected together at regular distances by lamellar expansions of the same material. The aggregate formation resulting from this combination of tubes constitutes a variously-shaped mass, which often attains a very considerable size.

In Fig. 77 we have a representation of the animal of *Tubipora musica* and its red corallum, which is sometimes designated by the common name of Organ Pipe Coral. In the engraving, 1 is the calcareous corallum, reduced to half its size; 2, is a portion about the natural size; 3, magnified, and containing the polyp which occupies the summit of the tube, and which forms this curious coral; 4, is the

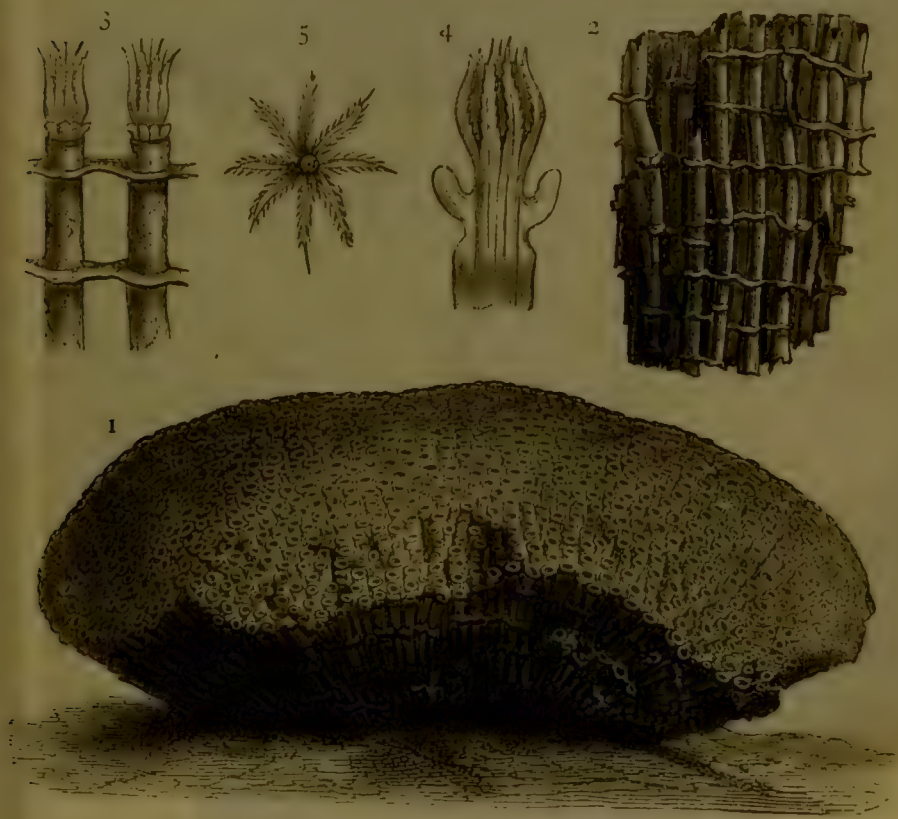


Fig. 77.—Tubipora musica (Linn.), half the natural size.

polyp magnified; 5, the crown of delicately-fringed tentacula of an individual polyp.

Zoologists of the last century confounded all the species of this genus inhabiting the tropical seas, making only one species, that to which Linnæus gave the name of *Tubipora musica*. But it is now known that there are several species of *Tubipora*, readily distinguishable in a fresh condition, among other things by a difference in the colour

of the polyps. The tissue of these singular beings is of an intensely red colour. The disposition of their tubes in the style of organ pipes has always attracted the attention of the curious inquirer into the secrets of Nature.

Fig. 78.—The Sea Fan, Gorgonia flabellum (Linn).

II. GORGONIDÆ.

Milne-Edwards divides this order into three natural groups:—I. The *Gorgoninæ*. II. The *Isidinæ*. III. The *Corallinæ*.

The *Gorgoninæ* are composed of two substances: the one external, sometimes gelatinous; sometimes, on the contrary, cretaceous, fleshy, and more or less tenacious. Animated with life, this membrane is irritable, and encloses the polyp; it becomes friable, and often peels off like bark in drying. The second substance, internal and central,

sustains the first, and is called the *axis*. This axis presents a horny appearance, and was formerly believed to possess chemical characters analogous to the horns and hoofs of some of the vertebrated animals. It has recently been asserted that the tissues of these corals consist

Fig. 79.—Fan Gorgon, magnified.

essentially of a particular substance which resembles horn, but which is called *Corneine*. A little carbonate of lime is sometimes found united with this substance, but never in a sufficient quantity to give it a stony consistence. The outer covering develops itself in concentric layers, between the portion of the axis previously formed and the internal surface of the basic covering.

Fig. 80.—Gorgonia verticellata (Pallas).

The mode of growth in this axis presents great variations. Sometimes it remains simple and rises like a slender rod, sometimes it has

numerous branches. It is *arborescent* when the branches and their accompaniments take different directions so as to constitute tufts. It is *panicled* when they arrange themselves on both sides of the stem or principal branches, after the manner of the barbs of a feather. It is *flabelliform* when the branches rise irregularly under the same plane; *reticulated*, when branches are so disposed as to be attached to each other by net-work in place of remaining free.

The *Gorgoninæ* are found in every sea, and always at considerable depths. They are larger and more numerous between the tropics than in cold or even temperate climates. Some of them scarcely attain the twelfth of an inch in height, while others rise to the height of several feet.

Fig. 81.
Gorgonia verticellata (Pallas), magnified four times.

Formed in the bosom of the ocean, it is only necessary to behold these singular creations in order to admire the brilliant colours which decorate their semi-membranaceous branches. The brilliancy of their colours is singularly diminished, has almost entirely disappeared indeed, when they make their appearance in the cases of our natural history collections.

The *Fan Gorgon* (*Gorgonia flabellum*), from the Antilles (Fig. 78), is a species which often attains the height of eighteen or twenty inches, and nearly as much in breadth. The network of its interstices, with its unequal and serried meshes, resembling fine lace, have led to its designation of *Sea Fan*. Its colour is yellow or reddish. In Fig. 79 we have a small portion of the Sea Fan magnified to twice its natural size, showing the curious details of its organisation.

The Whorled Gorgon (*G. verticellata*), which is found in the Mediterranean, is yellowish in colour, and also of elegant form. This species is represented in Fig. 80; while Fig. 81 represents a small branch magnified four times, in order to give an exact idea of its form.

The Gorgons are not known to be useful either in the arts or in medicine; but they are deeply interesting as objects of study to the zoologist.

ISIDINÆ.

The *Isidinæ* constitute an intermediate group between the *Gorgoninæ* and *Corallinæ*. Their polypidom is arborescent, but its axis is

Fig. 82.—Isis hippuris.

formed of articulations alternately calcareous and horny. The principal genus is that called *Isis*, which is met with in the Indian Ocean, on some parts of the American coast, and in the Pacific Ocean.

The inhabitants of the Molucca Islands use it medicinally as a remedy in certain diseases; but as they use it for the most opposite maladies, it may be doubted if it be really efficacious in any medicinal point of view.

The *Isis hippuris* of Lamarck has a coral with numerous slender branches, furnished with cylindrical knots at intervals, contracted towards the middle, finely striated, and rose-coloured; it is represented in Fig. 82, and has a singular resemblance to the Common Mare's Tail (*Hippuris vulgaris*).

Several other species belonging to this family are known. The same family includes the genera of *Melithea* and *Mopsea;* which, however, our limits forbid us to describe.

CORALLINÆ.

The group of Corallinæ consists of but a single genus, *Corallium* having a common axis, inarticulate, solid, and calcareous, the typical species of which furnishes a substance so hard, brilliant, and richly coloured, that it is much sought after as an object of adornment. This interesting Alcyonarian and its corallum require to be described in some detail.

From very early times this coral has been adopted as an object of ornament. From the highest antiquity, also, efforts were made to ascertain its true origin, and to assign to it its place in the scale of Nature. Theophrastus, Dioscorides, and Pliny considered that the coral was a plant. Tournefort, in 1700, reproduced the same idea. Réaumur slightly modified this opinion of the ancients, and declared his opinion that the coral was the stony product of certain marine plants. Science was in this state, when a naturalist, who has acquired a great name, the Count de Marsigli, made a discovery which threw quite a new light on the true origin of this product. He announced that he had discovered the flowers of the coral. He represented these flowers in his fine work, "La Physique de la Mer," which includes many interesting details respecting this curious product of the ocean. How could it be longer doubted that the coral was a plant, since he had seen its expanded flowers?

No one doubted it; and Réaumur proclaimed everywhere the discovery of the happy Academician.

Unhappily, a discordant note soon mingled in this concert; it even emanated from a pupil of Marsigli.

Jean André de Peyssonnel was born at Marseilles in 1694. He was a student of medicine and natural history at Paris when the

Académie des Sciences charged him with the task of studying the coral in a living state. Peyssonnel began his observations in the neighbourhood of Marseilles in 1723, and continued to pursue it on the North African coast, where he had been sent on a mission by the Government. Aided by a long series of observations, as exact as they were delicate, Peyssonnel demonstrated that the supposed flowers which the Count de Marsigli thought he had discovered in the coral, were nothing else but true animals, and showed that the coral was neither plant nor the product of a plant, but a being with life, which he placed in the first "rung" of the zoological ladder. "I put the flower of the coral," says Peyssonnel, "in vases full of sea-water, and I saw that what had been taken for a flower of this pretended plant was, in truth, only an animal, like a little sea-nettle, or polyp. I had the pleasure of seeing the feet of the creature move about, and having put the vase full of water, which contained the coral, in a gentle heat over the fire, all the small animals seemed to expand. The polyp extended his feet, and showed what M. de Marsigli and I had taken for the petals of a flower. The calyx of this pretended flower, in short, was the animal, which advanced and issued out of its cell."

The observations of Peyssonnel were calculated to put altogether aside the theories which had till then attracted universal admiration; but they were coldly received by the naturalists who were his contemporaries. Réaumur distinguished himself greatly in his opposition to the young innovator. He wrote to Peyssonnel in an ironical tone. "I think," he says, "as you do, that no one has hitherto been disposed to regard the coral as the work of an animal. We cannot deny that this idea is both new and singular; but the coral, as it appears to me, never could have been constructed by sea-nettles or polyps, if we may judge from the manner in which you make them labour."

What appeared impossible to Réaumur was, however, a fact, which Peyssonnel now demonstrated to hundreds by his experiments at Marseilles. Nevertheless, even Bernard de Jussieu did not find the reasons he urged strong enough to induce him to abandon the opinions he had formed as to their vegetable origin. Afflicted and disgusted at the indifferent success with which his labours were received, Peyssonnel abandoned his investigations. He even abandoned science and society, and sought an obscure retirement in the Antilles as a naval surgeon; and his manuscripts, which he left in France, have never been printed. These manuscripts, written in 1744, are preserved in the library of the Museum of Natural History at Paris. It should be added, in order to complete this recital, that

Réaumur and Bernard de Jussieu finally recognised the value of the discoveries and the validity of the reasoning of the naturalist of Marseilles. When these illustrious *savants* became acquainted with the experiments of Trembley upon the fresh-water Hydra; when they had themselves repeated them; when they had made similar observations on the sea anemone and alcyonium; when they finally discovered that on other so-called marine plants animals were found similar to the hydra, so admirably described by Trembley; they no longer hesitated to render full justice to the views of their former adversary.

While Peyssonnel still lived forgotten at the Antilles, his scientific labours were crowned with triumph at Paris; but it was a sterile triumph for him. Réaumur first gave to the animals which construct the coral the name of *Polyps*, and *Coral* to the product itself, which he at once recognised as the architectural product of the polyps. In other words, Réaumur introduced to the world of Science the very views which he had keenly contested with their author, and gave them a nomenclature that still endures. But from that time the animal nature of the precious coral has never been doubted.

Without pausing to note the various authors who have given their attention to the structure of this fine natural production, we shall at once direct ours to the organisation of the animals and the construction of the coral, as described by M. Duthiers.

M. Lacaze-Duthiers, one of the Professors at the Jardin des Plantes, of Paris, published in 1864 a remarkable monograph, entitled "L'Histoire Naturelle du Corail." This learned naturalist was charged by the French Government, in 1860, with a mission having for its object the study of the coral from its natural history point of view. His observations upon it are numerous and precise, and worthy of the successor of Peyssonnel.

A branch of *living* coral, if we may use the term, is an aggregation of animals derived from a first being by budding. They are united among themselves by a common tissue, each seeming to enjoy a life of its own, though participating in a common object. The branch owes its origin to an egg, which produces a young animal, which attaches itself soon after its birth, and from this is derived the new beings which, by their united labours, produce the branch of coral or polypidom.

This branch is composed of two distinct parts: the one central, of a hard, brittle, and stony nature, the well-known coral of commerce; the other external, like the bark of a tree, soft and fleshy, and easily impressed with the nail. This is essentially the layer of

the living colony. The first is called the polypidom, the second is the colony of polyps. Into this (Fig. 83) the polyps contract themselves when the water is withdrawn from the colony. It is covered with salient protuberances, much wrinkled and furrowed; these are the retracted polyps.

Each protuberance represents a polyp, and exhibits on its summit eight creases, radiating round a central pore, which presents a star-like appearance. This pore as it opens gives to the polyps the

Fig. 83.
Red Coral Polyps, retracted
(Lacaze-Duthiers).

Fig. 84.
Three Polyps of Red Coral
(Lacaze-Duthiers).

opportunity of coming out. Its edge presents a reddish calyx, like the rest of the bark, the festooned throat of which presents eight dentations.

The polyp itself (Fig. 84) is formed of a whitish membranous tube, nearly cylindrical, having an upper disc, surrounded by its eight tentacula, bearing many delicate pinnæ spreading out laterally. This assemblage of tentacula almost resembles the corolla of some flowers; its form is constantly changing, but it always presents a very pretty appearance. Fig. 85 (which is borrowed from M. Lacaze-Duthiers) represents another partially expanded polyp.

The arms of the polyps are at times subject to violent agitation: the tentacula become much excited. If this excitement continues, the tentacula can be seen to fold and roll themselves up, as shown in Fig. 86. If we look at the expanded disc, we see that the eight tentacula are attached to the body, around a space nearly circular, in the middle of which rises a small protuberance, the summit of which is occupied by a small slit forming two rounded lips. This is

Fig. 85.
Coral Polyp (Lacaze-Duthiers).

Fig. 86.
Another form of Coral Polyp (Lacaze-Duthiers).

the mouth of the polyp, the form each assumes is very variable, but it is well represented in Fig. 86, where the mouth is well seen.

A cylindrical tube connected with the mouth represents the œsophagus or gullet; but all other portions of the digestive canal are very rudimentary. The œsophagus connects the general cavity of the body with the exterior world, and looks as if it were suspended in the middle of the body by certain folds, which issue with perfect symmetry from eight points of its circumference. The folds which thus fix the œsophagus form a series of cells, above each of which it attaches itself, and supports an arm or tentaculum.

Let us pause an instant over the soft and fleshy bark in which the polyps are immersed. Let us see also what are the mutual relations which exist between the several inhabitants of one of these colonies, how they are attached to one another, and what is their connection with the polypidom.

The thick fleshy body, soft and easily impressed with the finger, is the living part which produces the coral; it extends itself so as exactly to cover the whole polypidom. If it perishes at any one point, that part of the axis which corresponds with the point no longer shows any increase. An intimate relation, therefore, exists between the bark and the polypidom. If the bark is examined more closely, three principal elements are recognised—a common general *tissue*, some *spicula*, and certain *vessels*. The general tissue is transparent, glossy, cellular, and contractile.

The spicules are very small calcareous bodies, more or less elongated, covered with knotted protuberances bristling with spines, and of a more or less regular determinate form (Fig. 87). They refract the light very vividly, and their colour is that of the coral, but much less vivid, in consequence of their want of thickness. They are uniformly distributed throughout the bark, and give to the coral the fine colour which generally characterises it when in a living state.

Fig. 87.—Coral Spicules (Lacaze-Duthiers).

The vessels constitute a network, which extends and repeats itself in the thickest of the bark. These vessels are of two kinds (Fig. 88); the one, comparatively very large, is imbedded in the axis, and disposed in parallel layers; the others are regular and much smaller. They form a network of unequal meshes, which occupies the whole thickness of the external crust. This network has direct and important connection with the polyps on the one hand, and with the central substance which forms the axis on the other. It communicates directly with the general cavity of the body of the animal, by every channel which approaches it, while the two ranges of network approach each other by a greater number of anastomosing processes. Such is the vascular arrangement of the coral.

The circulation of alimentary fluids in the coral is accomplished by means of vessels near to the axis, without, however, directly anastomosing with the cavities containing the polyps which live in the polypidom; they only communicate with these cavities by very delicate intermediary canals. The alimentary fluids they receive from the secondary system of network, which brings them into direct

communication with the polyps. The alimentary fluids elaborated by the polyps pass into the branches of the secondary and irregular network system, in order to reach the great parallel tubes which extend from one extremity of the organism to the other, serving the same purpose to the whole community.

Fig. 88.—Circulating Apparatus for the nutritive fluids in the Coral (Lacaze-Duthiers).

When the extremity of a branch of living coral is torn or broken, a white liquid immediately flows from the wound, which mingles with water, and presents all the appearance of milk. This is the fluid aliment which has escaped from the vessel containing it, charged with the *débris* of the organism.

What occurs when the bud produces new polyps? It is only

well-developed polyps, and particularly those with branching extremities, in which this phenomenon is produced. The new beings resemble little white points pierced with a central orifice. Aided by the microscope, we discover that this white point is starred with radiating white lines, the edge of the orifice bearing eight distinctly-to-be-traced indentations. All these organs are enlarged step by step until the young animal has attained the shrub-like or branched aspect which belongs to the compound polypidom. The tube is branching, and the orifices from which the polyps expand become dilated into cup-like cells.

The coral of commerce, so beautiful and so appreciated by lovers of bijouterie, is the polypidom. It is cylindrical, much channeled on the surface, the lines usually parallel to the axis of the cylinder, the depressions sometimes corresponding to the body of the animal. If the transverse section of a polypidom be examined, it is found to be regularly festooned on its circumference. Towards its centre certain sinuosities appear, sometimes crossing, sometimes trigonal, sometimes in irregular lines, and in the remaining mass are reddish folds alternating with brighter spaces which radiate from the centre towards the circumference (Fig. 89). In the section of a very red coral, it will be observed that the colour is not equally distributed, but is separated into zones more or less deep in colour, containing very thin preparations which crack, not irregularly, but parallel to the edge of the plate, and in such a manner as to reproduce the festoons on the circumference. From this it may be deduced that the stem increases by concentric layers being deposited, which mould themselves one upon the other. In the mass of coral certain small bodies (spicules) occur, with irregular asperities, much redder than the tissue into which they are plunged. These are much more numerous in the red than in the light band, and they necessarily give more colour to the general tint.

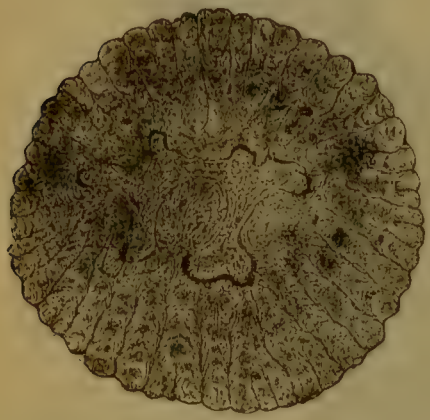


Fig. 89.—Section of a Branch of Coral. (Lacaze-Duthiers.)

To the mode of reproduction in the coral polyps, so well described by Lacaze-Duthiers, we can only devote a few lines. Sometimes,

according to this able observer, the polyps of the same colony are all either male or female, and the branch is *unisexual;* in others there are both male and female, when the branch is *bisexual.* Finally, but very rarely, polyps are found uniting both sexes.

The coral is viviparous; that is to say, its eggs become embryos inside the polyp. The larva remain a certain time in the general

Fig. 90.—Birth of the Coral Larva. (Lacaze-Duthiers.

cavity of the polyp, where they can be seen through its transparent body, as exhibited in Fig. 90. Aided by the magnifying powers of the microscope, coral larvæ may even be examined through the transparent membranous envelope. From this position they escape from the mouth of the mother in the manner represented in the upper branch. The larva then resembles a little white grub or worm, more or less elongated. The larva is, however, still egg-shaped or ovoid; moreover, it is sunk in a hollow cavity, and covered with cilia, by the

aid of which it can swim. Sometimes one of its extremities becomes enlarged, the other remaining slender and pointed. Upon this an opening is formed communicating with the interior cavity: this is the mouth. The larva swim backwards; that is to say, with the mouth behind.

It is only at a certain period after birth that the coral-polyp fixes itself and commences its metamorphoses, which consist essentially in a change of form and proportions. The buccal extremity is diminished, and tapers off, whilst the base swells, and is enlarged—it becomes discoid; the posterior surface of this disc is a plane, the

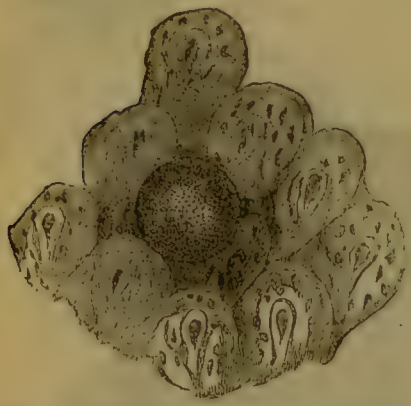


Fig. 91.—Very young Polpys, attached to a Bryozoon.

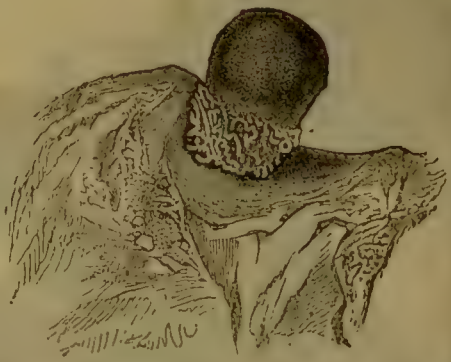


Fig. 92.—A young Coral Polyp fixed upon a Rock. (Lacaze-Duthiers.)

front representing the mouth, at the bottom of a depression edged with a great cushion. Eight protuberances or swellings now appear, corresponding to the chambers which divide the interior of the disc; the larva has taken its radiate form. Finally, the protuberances become elongated and transformed into tentacula. In Fig. 91 a young coral polyp is represented fixed upon a bryozoon. It forms a small disc, the fortieth part of an inch in diameter, and having its spicula already coloured red. Fig. 92 shows the successive forms of the young polyps in the progressive phases of their development—being a young coral polyp fixed upon a rock still contracted. Fig. 93 is a similar coral polyp attached to a rock and expanding its tentacula. Fig. 94 represents a small pointed rock covered with polyps and polypidoms of the natural size and of different shapes, but all young, and indicating the definite form of development which the collective beings are to assume.

The simple isolated state of the animal, whose phases of development we have indicated, does not last long. It possesses the property of producing new beings, as we have already said, by budding. But

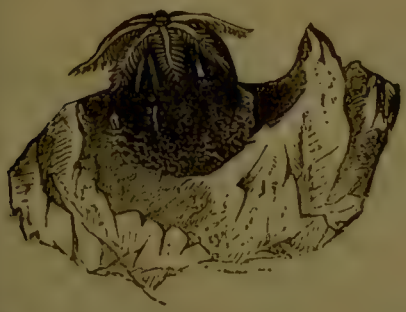


Fig. 93.—Young Coral Polyp attached to a Rock, and expanded. (Lacaze-Duthiers.)

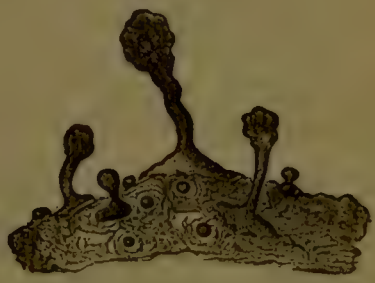


Fig. 94.—A Rock covered with young Polyp and Polypidom. (Lacaze-Duthiers.)

Fig. 95.—Corpuscles from which originate the Polypidom.

Fig. 96.—First form of the Polypidom. (Lacaze-Duthiers.)

how is the polypidom formed? If we take a very young branch, we find in the centre of the thickness of the crust a nucleus or stony substance resembling an agglomeration of spicula. When they are sufficient in number and size, these nuclei form a kind of stony plate,

which is imbedded in the thickness of the tissues of the animal. These *laminæ*, at first quite flat, assume in the course of their development a horse-shoe shape. Figs. 95 and 96 will give the reader some idea of the form in which the young present themselves. Fig. 95 represents the corpuscles in which the polypidom has its origin; Fig. 96, the rudimentary form of the coral polypidom.

Our present information does not enable us to say what time is necessary for the coral to acquire the various proportions in which it presents itself to the coral fisher.

Passing to the coral fishing, it may be said to be quite special, presenting no analogy with any other fishing in the European seas, if we except the sponge fisheries. The fishing stations which occur are found on the Italian coast and the coast of Barbary; in short, in most parts of the Mediterranean basin. In all these regions, on abrupt rocky beds, certain aquatic forests occur, composed entirely of the red coral, the most brilliant and the most celebrated of all the corals, *Coralium decus liquidi!* During many ages, as we have seen, the coral was supposed to be a plant. The ancient Greeks called it the *daughter of the sea* (Κοράλλιον κόρη ἁλός), which the Latins translated into *coralium* or *corallium*. It is now agreed among naturalists that the coral is constructed by a family of polyps living together, and composing a polypidom. It abounds in the Mediterranean and the Red Sea, where it is found at various depths, but rarely less than five fathoms, or more than 100. Each polypidom resembles, as we have seen, a pretty red leafless under-shrub, bearing delicate little star-like radiating white flowers. The axes of this little tree are the parts common to the association, the flowrets are the polyps. These axes present a soft reticulated crust, or bark, full of little cavities, which are the cells of the polyps, and they are permeated by a milky juice. Beneath the crust is the coral, properly so called, which equals marble in hardness, and is remarkable for its striped surface, its bright red colour, and the fine polish of which it is susceptible. The ancients believed that it was soft in the water, and only took its consistence when exposed to the air:—

> "Sic et coralium, quo primum contigit auras
> Tempore, durescit."—OVID.

The fishing is chiefly conducted by sailors from Genoa, Leghorn, and Naples, and it is so fatiguing that it is a common saying in Italy that a sailor obliged to go to the coral fishery should be a thief or an

VII.--Coral Fishing off the Coast of Sicily.

assassin. The saying is a gratuitous insult to the sailor, but conveys a good idea enough of the occupation.

The barks sent to the fishing range from six to fifteen tons; they are strong, and well adapted for the labour; their rig is a great lateen sail, and a jib or staysail. The stern is reserved for the capstan, the fishers, and the crew. The fore part of the vessel is reserved for the requirements of the padrone or master.

The lines, wood, and irons employed in the coral fisheries are called the *engine:* it consists of a cross of wood formed of two bars, strongly lashed or bolted together at their centre; below this a great stone is attached, which bears the lines, arranged in the form of a sac. These lines have great meshes, loosely knotted together, resembling the well-known swab.

The apparatus carries thirty of these sacs, which are intended to grapple all they come in contact with at the bottom of the sea. They are spread out in all directions by the movement of the boat. The coral is known to attach itself to the summit of a rock and to develop itself, forming banks there, and it is to these rocks that the swab attaches itself so as to tear up the precious harvest. Experience, which in time becomes almost intuitive, guides the Italian fisher in discovering the coral banks. The craft employed in the great fishery have a "padrone," or captain, the bark having a crew of eight or ten sailors, and in the season it is continued night and day. The whole apparatus, and mode of using it, is shown in PLATE VII.

When the padrone thinks that he has reached a coral bank, he throws his engine overboard. As soon as the apparatus is fairly at the bottom the speed of the vessel is slacked, the capstan is manned by six or eight men, while the others guide the helm and trim the sails. Two forces are thus brought to act upon the lines, the horizontal action of the vessel and the vertical action of the capstan. In consequence of the many inequalities of the rocky bottom, the engine advances by jerks, the vessel yielding more or less, according to the concussion caused by the action of the capstan or sail. The engine seizes upon the rugged rocks at the bottom, and raises them to let them fall again. In this manner the swab, floating about, penetrates beneath the rocks where the coral is found, and is hooked on to it. To fix the lines upon the coral and bring them home, is a work of very great labour. The engine long resists the most energetic and repeated efforts of the crew, who, exposed half naked to the burning sun of the Mediterranean, work the capstan to which the cable and engine are attached, while the padrone urges and excites them to increased exertion; the sailors meanwhile trim the sails and sing

with a slow and monotonous tone a song, the words of which improvise in a sort of psalmody the names of the saints most revered among the seafaring Italian population.

The lines are finally brought home, tearing or breaking blocks of rock, sometimes of enormous size, which are brought on board. The cross is now placed on the side of the vessel, the lines are arranged on the deck, and the crew occupy themselves in gathering the results of their labour. The coral is gathered together, the branches of the precious alcyonarian are cleansed, and divested of the shells and other parasitic products which accompany them; finally, the produce is carried to and sold in the ports of Messina, Naples, Genoa, or Leghorn, where the workers in jewellery purchase them. Behold, fair reader, with what hard labour, fatigue, and peril, the elegant bijouterie with which you are decked is torn from the deepest bed of the ocean!

III. THE PENNATULIDÆ, OR SEA-PENS.

This curious family received from Cuvier the name of *Swimming Polyps*, and from Lamarck that of *Floating Polyps*. The name of *Pennatula*, by which they are now generally known, is taken from their resemblance to a quill, *penna*. In the words of Lamarck, "It seems as if Nature, in forming this composite animal, had wished to copy the external form of a bird's feather." Our fishermen call it the *cock's comb*, which is not inapt, but less expressive of its peculiarities. One of these Sea-pens is described as being "from two to four inches in length, of a uniform purplish-red colour, except at the tip or base of the stalk, where it is pale orange-yellow; the skin is thickish, very tough, and of a curious structure, being composed of minute crystalline cylinders, densely arranged in straight lines, and held together by a tenacious glutinous matter, the cylinders being about six inches in diameter, in length straight and even, or sometimes slightly curved, and of a red colour, which communicates itself to the zoophyte." (Johnston.) The animals by which it is formed constitute colonies, which, however, are only attached to the rocks by the enlarged basis of their stem; they appear to live generally at the bottom of the sea, their root, if we can use the term, buried in the sands or mud, their polypiferous portion sallying into the water. The agitation of the waves and the fishermen's nets often displace these curious creatures, and then they float away at various depths up to the bosom of the ocean.

The stalk of their polypidom is hollow in the centre, having a long slender bone-like substance, which is white, smooth, and square

but tapering at each extremity to a fine point. The polyps, which are fleshy and white, are provided with eight long retractile tentacula, beautifully ciliated on their inner edge with two series of short processes strengthened with crystalline spicula. The mouth in the centre of the tentacula is somewhat angular, bounded by a white band, a process from which seems to encircle the base of each tentaculum, which thus seems to issue from an aperture. The ova lie between the membranes of the pinnæ; they are globular, of a yellowish colour, and by a little pressure can be made to pass through the mouth. The polyps are distributed with more or less regularity in such a manner that one of the extremities of the common axis is always naked: this part has been compared to the tubulous part of a feather. The stem, common to the colony, is a solid central axis, more or less developed, which is covered with a fleshy fibrous substance, susceptible of dilatation and contraction.

The *Pennatulidæ* comprehend, according to Dr. Johnston, three genera; namely, those with the polyps or bipinnate wings, having

Polypidoms plumose, in	Pennatula.
Polypidoms virgate, or wand-shaped . .	Virgularia.
Polypi, unilateral and sessile . . . . } Polypidom, linear-elongate . . . }	Pavonaria.

In the genus *Pennatula*, the polyps are disposed in transverse rows upon the outer and inner edge, in a series of prolongations in the form of a feather. These winged species of polypidom are somewhat scythe-shaped, well-developed, and furnished with a great quantity of pointed spiculæ, which are constituted of bundles at the base of the calyx of each polyp. The space between the two rows of appendages is sometimes scaly, sometimes granulous Of the *Pennatula*, at least five species are known, and all of them appear to be endowed with phosphorescent properties. We may note among these species *Pennatula spinosa* (Fig. 97), which inhabits the Mediterranean, and takes its name from its colour; *Pennatula phosphorea*, which abound in most European seas, being found in great plenty, clinging to the fishermen's lines round our own northern shores, more especially when they are baited with mussels.

P. phosphorea is of a reddish purple, the base of the smooth stalk pale; the raches roughened with close-set papillæ, and furrowed down the middle; pinnæ close; polyp cilia uniserial, tubular, with spinous apertures. (Sibbald).

Bohadsch says the *Pennatulæ* swim by means of their pinnæ, which they use as fishes do their fins. Ellis says, "It is an animal

that swims about in the sea, many of them having a muscular motion as they swim along;" these motions being effected, as he tells us in another place, by means of the pinnules or feather-like fins, "evidently designed by Nature to move the animal backward or forward in the sea." Cuvier tells us they have the power of moving by the contraction of the fleshy part of the polypidom, and also by the combined action of its polpys. Dr. Grant says, "A more singular and beautiful spectacle could scarcely be conceived than that of a deep purple *P. phosphorea* with all its delicate transparent polypi expanded, and emitting their usual brilliant phosphorescent light, sailing through the still and dark abyss, by the regular and synchronous pulsations of the minute fringed arms of the whole polypi;" while Linnæus tells us that "the phosphorescent sea-pens which cover the bottom of the ocean cast so strong a light, that it is easy to count the fishes and worms of various kinds which sport among them."

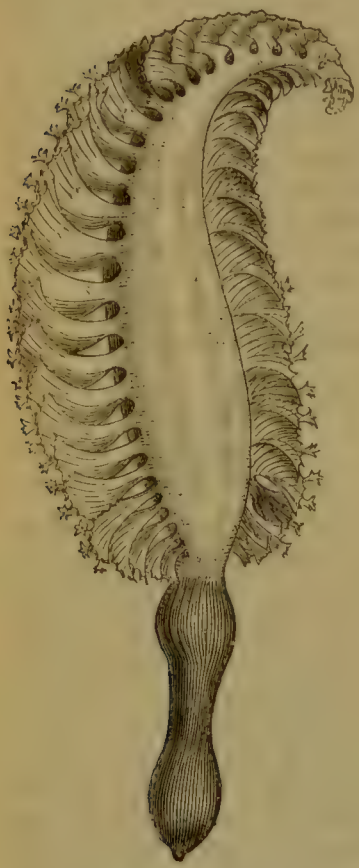


Fig. 97.—Sea-pen, *Pennatula spinosa.* (Edes.)

Lamarck, Schweigger, and other naturalists, however, reasoning from what is known of other such animals, deny them the existence of this locomotive power; "and there is little doubt," says Dr. Johnston, "that these authors are right, for, when placed in a basin of sea-water, the *Pennatulæ* are never observed to change their position; they remain in the same spot, and lie with the same side up or down, just as they have been placed. They inflate the body until it becomes to a considerable degree transparent, and only streaked with intercepted lines of red, which distend at one place and contract at another; they spread out the pinnæ, and the polyps expand their tentacula, but they never attempt to swim, or perform any process of locomotion."

Mr. Darwin's description of a kind of Sea-pen, *Virgularia Pata-*

gonia, throws some curious light on the habits of these creatures. "This zoophyte consists of a thin, straight, fleshy stem, with alternate rows of polypi on each side, and surrounding an elastic stony axis, varying in length from eight inches to two feet. The stem at one extremity is truncate, but at the other is terminated by a vermiform fleshy appendage. The stony axis, which gives strength to the stem, may be traced at the extremity into a mere vessel filled with granular matter. At low water, hundreds of these zoophytes might be seen projecting like stubble, with the truncate end upwards, a few inches above the surface of the muddy sand. When touched or pulled, they suddenly drew themseves in with force, so as nearly, or quite, to disappear. By this action, the highly elastic axis must be bent at the lower extremity, where it is naturally slightly curved; and I imagine it is by this elasticity alone that the zoophyte is enabled to rise again through the mud. Each polyp, though closely united to its brethren, has a distinct mouth, body, and tentacula. Of these polyps, in a large specimen there must be many thousands, yet we see that they act by one movement. They have also one central axis connected with a system of obscure circulation, and the ova are produced in an organ distinct from the separate individuals. For," adds Mr. Darwin, in a note, "the cavities leading from the fleshy compartments of the extremity were filled with a yellow pulpy matter which, under a microscope, consisted of rounded semi-transparent grains aggregated together into particles of various sizes. All such particles, as well as separate grains, possessed the power of rapid motion, generally revolving round different axes, but sometimes progressive."

Virgularia mirabilis is common in the east and north coasts of Scotland; it is found in the North Sea, and as far north as Norway. In Zetland it is known as the sea-rush. It is abundant in Belfast Lough, but, from its brittle nature, perfect specimens are difficult to obtain.

The genus *Virgularia* differs from that of *Pennatula* chiefly in the development of the axis of the colony and the shortness of the pinnæ, which carry the polyps; and also in this, that no spicula enter into the composition of its softer parts.

"*V. mirabilis* seems," says Sowerby, "to represent a quill stripped of its feathers. The base looks like a pen in this as in other species, swelling a little way from the end, and then tapering. The upper part is thicker, with alternate semicircular pectinated swellings, larger towards the middle, tapering upwards, and terminating in a thin bony substance, which passes through the whole extent, and is from six to ten inches in length."

In a communication to Dr. Johnston, from Mr. R. Patterson of Belfast, commenting on Müller's figure of *Virgularia*, he tells us that in the longest specimen he had, no two plumes were precisely alike; so unlike, indeed, that the artist copying one, could not for a moment hesitate—after raising her eyes from her paper to look at the animal—as to which she was copying.

Its short waving and deeply dentated lobes are of a brilliant yellow. The polyps, which appear upon the lobes, are whitish, transparent, and form a fringe of small diaphanous white stars (Figs. 98 and 99).

V. mirabilis is undoubtedly one of the finest polypidoms found in the ocean. Two series of half-moon shaped wings, obliquely horizontal, are placed symmetrically round an upright axis. They embrace the stem somewhat in the manner termed *petiolate* by botanists, clasping it alternately; or, shall we say, like two broad ribbons rolled round a stem in an inverse direction, in such a manner as to produce the effect of two opposing flights of stairs. These wings are waving, vandyked, and fringed on their outer edge, and of a brilliant yellow; the toothing of the fringe being the lodging-place of the pretty little polyps, which display occasionally their gaping mouths and expanded tentacles. The polyps are white and semi-transparent. When they display their rays, the margin of each wing presents an edging of silvery stars. We may figure to ourselves a slender wand-like and much-elongated polypidom, carrying only a non-contractile polyp on one side, which would give us an idea of the genus Pavonaria, of which we know only one species, which is from the Mediterranean.

The *Umbellularia grenlandica* has a very long stem (Fig. 100) which is terminated at the summit only by a cluster of polyps. It has been found in the Greenland and other northern seas.

The *Veretillum cynomorium* which inhabits the Mediterranean (Fig. 101), has a simple cylindrical body, without branchiæ, and a rudimentary polypidom, furnished with very large polyps of a whitish colour.

IV.—THE ALCYONIDÆ.

The animals which compose this group have the fleshy polypidom always adherent, without axis or solid interior stem. They are divided into four families or tribes. One of these, the *Cornularidæ* are polyps either living in isolation, or gathered together in small numbers on the surface of a common membraniform expansion. The *Cornularia cornucopia* is found on the coast of Naples, *C. crassa* on

Fig. 98.—Loose-winged Virgularia, *Virgularia mirabilis* (Lamarck).

Fig. 99.—Branch of Virgularia (enlarged).

Fig. 101.—Veretillum cynomorium (Lamarck).

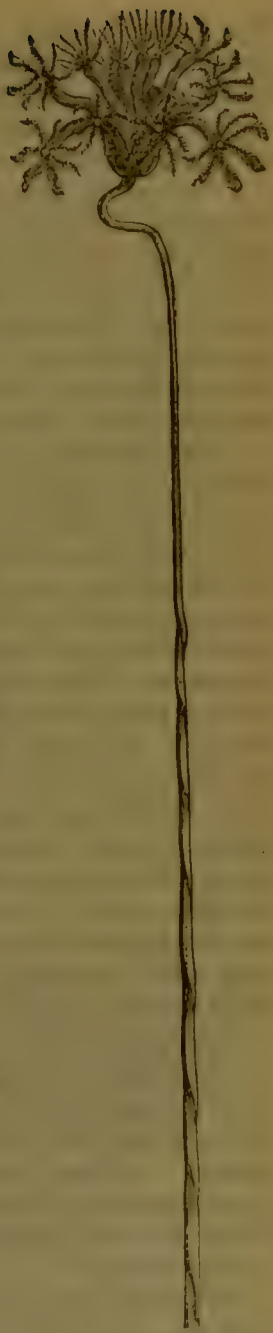


Fig. 100.—Umbellularia grenlandica (Lamarck).

the Algerian coast. Other genera make their appearance on the coast of Scotland, of Norway, in the Red Sea; and in the Indian Ocean they appear in great numbers.

In the *Alcyonidæ*, properly so called, the polypidom is very thick, of a semi-cartilaginous consistence, granular, and rough to the touch.

The genus *Alcyonium* is numerous in species which are widely dispersed. *A. digitatum* is very common on our shores; and on many parts of the coast scarcely a stone or shell is dredged up from deep water which does not serve as a support to some one or more species of *Alcyonium*. It is known by various popular names by our sea-side population, such as *cows' paps*, from its resemblance to the teats of the cow; *dead man's fingers*, from the occasional resemblance of its finger-like lobes to a man's fingers.

The outer skin of the polypidom is tough and coriaceous, studded all over with star-like figures, which on examination are found to be divided into eight rays, indicating the number of the polyps enclosed in its semi-transparent membrane. Each polyp is dotted over with minute calcareous bodies, and marked with eight longitudinal lines or septa, stretching between the membrane and the central stomach, which divide the intermediate space into an equal number of compartments. These lines not only extend to the base of the tentacula, but run across the oral disc, and terminate in a central mouth. The tentacula are short, obtuse, ciliated on the margins, and strengthened at their roots by numerous calcareous spicula. The polyp cells are oval, placed just under the investing membrane, and are the terminating points of certain long canals which traverse the whole polypidom. The polyps, which are distributed over the whole surface, can withdraw into the cavities; they are, besides, of extreme sensibility, the least shock impresses itself on the tentacula, the impulse of a wave even producing contraction, in response the animal immediately retires to hide itself in the cell.

We find, as we have said, on the coast, in the Channel, and in the North Sea, *Alcyonium digitatum*, the mass of which is of a reddish white, ferruginous, or orange colour. *A. stellatum*, found on the shores of the Mediterranean, is expanded in its upper part, narrow towards its base, very rough on the surface, and rose-coloured; *A. palmatum* is cylindrical, branching at the summit, of a deep red, except at the base, where it is yellow—this is met with in the Mediterranean.

We may note as a type altogether different from any yet touched upon the genus *Nephthya*, in which the polypidom is a coriaceous tissue bristling with spicula over its whole surface. In *N. Chabrolii*,

the polypidom is squat, with thick spreading arms covered with lobiliform branches, the tubercular polypidoms of which are columnar and obtuse, the spicula green, and the tentacula of the polyps yellow.

"On a cursory view," says Dr. Johnston, "the polypidom of the three families embraced appear very dissimilar, and accordingly, by many recent authors, they have been scattered over the class, and placed widely asunder. The affinity between them, however, is generally acknowledged, and had been distinctly perceived by some of the earliest zoophytologists. Thus Bohadsch found so much in common in the typical Pennatula and a species of *Alcyonium*, that he has not hesitated to describe them as members of the same genus; and, although the more systematic character of Pallas prevented him from falling into this error, if error it can be called, he did not the less recognise the relationship between the genera or families. Pallas also tells us that his *Verretillum cynomorium* differs from the *Alcyonium* only in this, that the former is a movable and the latter a fixed polypidom; and he saw with equal clearness the connection which exists between these genera and the shrub-like *Gorgonia*. Of the *Virgularia mirabilis*, he had doubts whether it was not rather a species of *Gorgonia*, until he perceived that the stem was attenuated at each end, and free; and of the Sea-pens generally, Ellis remarks that they are 'a genus of zoophytes not far removed from the *Gorgonia*, on account of their polyp mouths, as well as having a bone in the inside and flesh without.' 'On the other hand, the *Gorgonia* seem,' says Pallas, 'with the exception of their horny skeleton, to be nearly similar in structure to the genus *Alcyonium;* but as there are species of *Gorgonia* which are suberose internally, and almost of a uniform medullary consistence, even this mark of distinction fails to separate the tribes, and we have little left to guide us in arranging these osculent species excepting their external habits.'"

"With most corallines," says Frédol, "the elementary individual, in spite of the adhesion established among them, possesses a vital energy all its own; it is in some respects quite independent. They have each its own particular will, which it is difficult to mistake for a common will; but it is not thus with the *Pennatula*. Their association consists of a non-adherent polyp, which moves—obscurely, it is true—but still it moves. To what does this lead? To this: that the parts which they possess in common, in place of being horny or calcareous—that is, completely inert—are fleshy, with contractile powers; that is to say, animated. Consequently, the polyp of the *Pennatula* are less independent of each other than

the coral polyp, which have a central, perhaps a sensible organ, common to all, which binds them to each other, giving a certain unity to their acts. The Gorgonian polyps have no will; the *Pennatula* have."

CTENOPHORA.

We have now reached the class of polyps which Cuvier designates *Hydrostatic Acalephæ*, and which De Blainville calls the *Ciliobranchiata*. The body of these polyps presents marginal fringes furnished with vibratile cilia, which are swimming organs. Moreover, as these vibratile fringes are inserted directly over the principal canal, in which the nourishing fluid circulates, they ought necessarily to help in the act of respiration, by determining the renewal of the water in contact with the corresponding portion of the tegumentary membrane.

The class may be divided into five families, namely, *Callymmidæ*, *Cestidæ*, *Callianiridæ*, *Pleurobrachiadæ*, and *Beröidæ*.

The creatures belonging to these families swarm in the deep sea; they often appear quite suddenly, and in vast numbers, in certain localities.

Beröe Forskalii (Fig. 102), has been studied with great care by M. Milne-Edwards. The species inhabits the Gulf of Naples, and the sea almost everywhere; the sailors of Provence call them Sea-cucumbers. The body (Fig. 102), cylindrical in form, is of a pale rose colour, thickly studded with small reddish spots, so numerous as to appear entirely punctured with them. It presents eight blue sides, with very fine vibratile cilia, which by their reflection produce all the colours of the rainbow. The substance of the body is gelatinous, its appearance glass-like; its form varies according as the animal is in motion or repose. Sometimes it swells up like a ball; sometimes it reverses itself, so as to resemble a bell; at others it is elongated and cylindrical; at its lower extremity it presents a large mouth; at its upper extremity is found a small nipple, having at its base a spherical point of a reddish colour, enclosing many crystalloid corpuscles, which rest upon a sort of nervous ganglion, whose physiological function is not very well determined. A vast stomach, considering its size, occupies the whole interior of the body of the Beröe: the circulation is also much developed in this creature. The circulating apparatus contains a moving fluid charged with a multitude of circular, colourless globules, which flows from a vascular ring round the mouth towards the summit of the body; in the interior are eight superficial canals, which flow under the ciliated

sides, and re-descend by two much deeper canals; the Beröes have no heart. *Beröe ovata* is a beautiful species, seldom exceeding two inches and a half in length and one and a half in its larger transverse diameter; it is described by Browne, in his "Jamaica," as "of

Fig. 102.—Beröe Forskalii (Edwards).

an oval form, obtusely octangular, hollow, open at the larger extremity, transparent, and of a firm gelatinous consistence; it contracts and widens with great facility, but is always open and expanded when it swims or moves. The longitudinal radii are strongest in the crown or smallest extremity, where they rise from a

very beautiful oblong star, and diminish gradually from thence to the margin, each being furnished with a single series of short, slender, delicate appendages, or limbs (cilia), that move with great celerity in all directions, as the creature pleases to direct its flexions, and in a regular accelerated succession from the top to the margin. It is impossible to express the liveliness of the motions of those delicate organs, or the beautiful variety of colour which rise from them as they play to and fro in the rays of the sun; nor is it easy to express the speed and regularity with which the motions succeed each other from one end of the rays to the other." "The grace and beauty which the entire apparatus presents in the living animal," says Gosse, "or the marvellous ease and rapidity with which it can be alternately contracted, extended, and bent at an infinite variety of angles, no verbal description can sufficiently treat. Fortunately the creature is so common in summer and autumn on all our coasts that few who use the surface-net can possibly miss its capture. It is worthy of a poet's description, which it has received:—

> 'When first extracted from her native brine,
> Behold a round, small mass of gelatine,
> Or frozen dewdrop, void of life and limb;
> But round the crystal goblet let her swim
> 'Midst her own elements; and lo! a sphere
> Banded from pole to pole; as diamond clear,
> Shaped as bard's fancy shapes the small balloon,
> To bear some sylph or fay beyond the moon.
> From all her bands see lurid fringes play,
> That glance and sparkle in the solar ray
> With iridescent hues. Now round and round
> She whirls and twirls; now mounts, then sinks profound.'"
>
> DRUMMOND.

The species of *Pleurobrachia* (Flem.) are globulous or egg-shaped, furnished with eight rows of cilia, corresponding with as many sections more or less distinct, and terminated by two long filiform tentacles, issuing from the base of the zoophyte and fringed on the sides. "It is," says Gosse, "a globe of pure colourless jelly, about as big as a small marble, often with a wart-like swelling at one of its poles, where the mouth is placed. At the other end there are minute orifices, and between the two passes the stomach, which is flat or wider in one diameter than the other." *Pleurobrachia pileus*, found abundantly in the spring on all our coasts, is so transparent that it is scarcely visible in the water, where it seems like living, moving crystal. *Pl. densa*, which abounds in the Mediterranean, is of a crystalline white, with rows of reddish cirrhi, terminating in two

entacles, much longer and coloured red; it is about the size of a hazel-nut, and phosphorescent. Within the clear substance of the *Pleurobrachia*, on each side of the stomach, there is a capacious cavity, which communicates with the surface, and within each cavity is fixed the tentacle, of great length, and very slender, which the

Fig. 103.—Cestum veneris (Lesueur).

animal can at pleasure shoot out of the orifice and suffer to trail through the water, shortening, lengthening, twisting, twining, or contracting it into a tiny ball at will, or withdrawing it into its cavity, short filaments being given off at intervals over the whole length of this attenuated thread-like apparatus, each of which can also be lengthened or shortened, and coiled individually. These proceed only from one side of the thread-like tentacle, although, at a casual

glance, they seem to proceed now from one side, now from the other.

The family *Callianiridæ* forms a sort of connecting link between the *Pleurobrachiadæ* and the *Cestidæ*. Their bodies are smooth and regular, vertically-elongated, compressed on one side and as it lobated on the other; in substance they are gelatinous, hyaline, and tubular, obtuse at both extremities, with buccal openings between the prolongations of the sides, and two pairs of conical appendages resembling wings, capable of expansion, on the edges of which two rows of vibratory cilia are ranged. A great transversal opening presents itself at one of the extremities, a small one at the other. The animal is furnished with two branching tentacles, but without cilia.

In the family *Cestidæ* we have the genus *Cestum*. *C. veneris*, or Venus's Girdle, as it is vulgarly called, has a long, gelatinous, ribbon-like body, fine, regular, and very short, but much extended on each side, while the edges are furnished with a double row of cilia; the lower surface is also furnished with cilia, but much smaller in size and number. On the middle of the lower edge is the mouth, opening into a large stomach. This alimentary canal runs across the middle of its length, and from it extends, as in the Medusæ, a series of gastric canals, which carry the nutriment into all parts of the body. There are many species of Cestum; among them the best known is *C. veneris* (Fig. 103), which is found in the Mediterranean, particularly in the sea which bathes the coast of Naples and Nice, where the fishermen call it the *sabre de mer*—sea-sabre. This curious creature unwinds itself on the bosom of the waters, like a scarf of iridescent shades. It is the scarf of Venus traversing the waves, under the fiery rays of the sun, which has coloured it with a thousand reflections of silver and azure blue.

In the last family, *Callymmidæ*, the body is furnished with a pair of antero-posterior oral lobes and other smaller lateral appendages. The tentacles are various, and turned towards the mouth.

CHAPTER IX.

ECHINODERMATA.

"Ultra magis pisces et Echinos æquora celent."—HOR. *Ep.*

IN their "Natural History of the Echinodermata," Messrs. Hupé and Dujardin divide this vast natural group into five orders or families, namely: 1, *Crinoïdeæ*, stone lilies, calcareous, stem composed of movable pieces; 2, *Asteroïdeæ*, which includes the true star-fishes; 3, *Ophiurideæ*, having the disc much depressed, the rays simple, sometimes much divided; 4, *Echinidæ*, comprehending the animals known as sea-eggs, or sea-urchins, distinguished by their rounded form and absence of arms; 5, *Holothuroïdeæ*, with soft lengthened cylindrical body, covered with scattered suckers.

The Echinodermata (from the Greek words ἐχῖνος, rough, and δέρμα, skin, indicating an animal bristling with spines like the hedge-hog) are animals sometimes free, sometimes attached by a stem, flexible or otherwise, and radiating, that is presenting an appearance more or less regular in all its parts, after the manner of a circle or star, its form being globular, egg-shaped, cylindrical, or like a pentagonal plate; or lastly, like a star, with more or less elongated arms, which secrete either in all their tissues or only in the integument, very numerous symmetrical calcareous plates of solid matter, sometimes forming an internal skeleton or regular shell covered with a more or less consistent skin, often pierced with holes, from which the feet issue; they are frequently furnished with appendages of various kinds, such as spines, scales, &c.

The organisation of the Echinodermata is among the most perfect of all the annulose animals, serving as a transition between them and animals of more complicated frame. They have a digestive and vascular system, and a muscular system is almost always present; they have also either internal or external respiratory organs, and a rudimentary nervous system has been detected in many of the species. The nutritive system is very simple, presenting in some families a

single orifice in the centre of the lower surface of the body, destitute of teeth, performing the functions both of mouth and anus. De Blainville says that "the liver is well marked and rather considerable in the star-fishes, forming bunches occupying the whole circumference of the stomach, and extending to the cavities of the appendages where these exist." The mouth and gullet is admirably adapted for securing the testaceous molluscs and other substances on which they feed.

Reproduction in the Echinodermata appears to be monœcious. Ovaries are, as far as is known, present in all the female forms. They vary in number in different species. The sexes are usually separate: the young are produced by eggs, the embryo of which undergo important metamorphoses. Immediately after birth, the young star-fishes have a depressed and rounded body, with four club-shaped appendages or arms at their anterior extremity. When they are a little more developed, papillæ may be observed on the upper surface, in fine radiating rows: after twelve days the fine rays begin to increase, and after eight days more two rows of feet, or ambulacra, are developed under each ray, which assist in the locomotion of the animal by alternate elongation and contraction, performing also the office of suckers. Like most other of the lower animals, they have the power of reproducing parts of their bodies which may have been accidentally destroyed.

Most *star fishes* have five perfectly equal arms. They resemble a cross of honour, which has five branches. The *star of the brave*, the *star of honour*—these somewhat trivial words recall, nevertheless, the resemblance which exists between the two objects; doubtless, man has here taken Nature for his copy. It must, however, be remarked that, though five is the general number of arms in the star-fish, this number is not constant; it varies with different genera, species, and even with individuals. The connection of the arms with the disc presents equally remarkable differences. In the genus *Culcita*, the disc is so much developed that it constitutes, so to speak, the entire animal, whilst the arms form only very slight protuberances upon its circumference. In the genus *Luidia*, on the contrary, the disc is reduced to a minimum, whilst the arms are of great length, and very slender.

The colours of the many species of *star-fish* vary greatly; they vary from a yellowish-grey, a yellow-orange, a garnet-red, to a dark violet.

Star-fishes are exclusively and essentially inhabitants of the sea; they are never met with in fresh water; many of them dwell amongst the submarine plants, others are found on sandy coasts; they generally

are found at moderate depths, but there are some species which are found at the great depth of 1,250 fathoms.

Star-fishes are met with in almost every sea and under all latitudes, but they are most numerous and their forms are more richly varied in the seas of tropical regions.

Fig. 104.—Asterias rubens (Lamarck).

The body of the Asterias is supported by a calcareous envelope composed of juxta-imposed pieces at once various and numerous. The number of these pieces is estimated at more than 11,000 in the Red Sea Star-fish (*Asterias rubens*, Fig. 104), a species very common in Europe. The body of the *Asterias rubens* is likewise furnished with spines, granules, and tubercles, the shape, number, and disposition of which serve in many cases to characterise the genera and the species.

Another species, *Asterias aurantiaca*, will give a good idea of the general type of the animals in this order. This Echinoderm, which is represented in Fig. 105, is common in the northern seas; it has five rather long arms, furnished with spines, which are of an orange

105.—Asterias aurantiaca Lamarck).

colour—hence its name. When we see one of these animals stranded upon the shore, it appears to be entirely destitute of all power of progression. But it is by no means immovable; it is provided with a special apparatus for locomotion, consisting of membranous tubes usually termed feet, or ambulacra, which issue from the ambulacral apertures; but besides these, the rays themselves are movable, and, in animals which are free to move from place to place, these are perhaps used for the purpose. Thus, in the common star-fish the rays may be bent towards the upper or lower surface of the disc, so as to facilitate its

advance either in water, over small spaces, or up the vertical face of rocks. The ambulacral feet are very numerous, disposed in rows along the under surface of the rays; thus, in *A. aurantiaca* there are two simple rows of ambulacral feet attached to each ray, and the vesicular part is deeply cleft into two lobes; while in *A. rubens* (Fig. 105) there are two double rows of ambulacral feet on each ray, and each ambulacral foot has at its base a closed ambulacral vesicle.

Each of these ambulacral feet consists of two parts, an internal and generally bladder-like portion placed within the body, and a tubular portion outside, projecting from the surface through an aperture in the skin or shell, the tube being closed at the extremity, and terminating in a sucker, usually in the form of a disc slightly depressed in the centre; around the margin of this sucker-like extremity will be often found pretty rosette-like shaped calcareous plates, better seen in the Echinidæ. The feet are thus muscular fleshy cylinders, hollow in the centre, and very extensible; by means of them the animal draws itself forward. The foot is extended by the contraction of its internal ambulacral vesicle, which forces the ambulacral fluid into the hollow tube, or, where the ambulacral vesicle is wanting, by projecting the fluid into the tube by a communicating vessel. The tubular part is thus distended and elongated, and again retracts itself by means of its muscular fibres, by which action the fluid is forced back into the interior. In progression the animal extends a few of its feet, attaches its suckers to the rocks or stones, then, by shortening its feet, it draws its body forward. The progression of the Asterias is thus very slow, and so regular that only the closest observation enables the spectator to discover the movement which produces it. Like the movements of the hands of a watch, the eye cannot quite follow it. When an obstacle presents itself—if, for example, a stone comes in its way—it raises one of the rays in order to obtain a point of support, then a second ray, and if necessary a third, and thus the animal creeps over the stone with as much ease as if it walked over the smooth sands. In the same way the animal creeps up perpendicular rocks, which is accomplished by means of these ambulacral feet and their suckers. Frédol says: "If an Asterias is turned upon its back it will at first remain immovable, with its feet shut up. Soon, however, out come the feet like so many little feelers; it moves them backward and forward, as if feeling for the ground; it soon inclines them towards the bottom of the vase and fixes them one after the other. When it has a sufficient number attached the animal turns itself round. It is not impossible, whilst walking on the sea-shore, to have the pleasure of seeing one of these

star-fishes walking upon the sand. A day rarely passes without one of them being thrown upon the strand by the tide, and then abandoned by the retreating waters. Generally they are left dead: this is not always the case, however; they are sometimes only benumbed. Place them in a vase full of sea-water, or simply in a pool on the shore, and you will sometimes see them recover from this death-like condition, and execute the curious movements of progression which we have described. The motions of an Asterias thus saved form a very curious spectacle.

The mouth of this animal is situated on the lower surface of the disc. At this point the constitutive pieces of the body skeleton leave a circular space, covered by a fibrous resistant membrane, pierced at the centre by a rounded opening. This opening is sometimes armed with hard papillæ, which play the part of teeth. The mouth almost directly abuts on the stomach, which is merely a globular sac, filling nearly all the central portion of the visceral cavity.

"Thus," says M. Milne-Edwards, "in *Asteracanthion glacialis* the stomach is globular, but imperfectly divided into two parts by a fold of its internal membrane; the first chamber, thus limited, appears to be more especially devoted to the transformation of the elementary matter into a liquid paste, which passes, in small portions, into the upper chamber. This is passed onward through a small intestine, and communicates laterally with five cylindrical prolongations, which each divide themselves again into two much elongated tubes, furnished with a double series of hollow branches each terminating in a *cul-de-sac*." These organs are protruded into the interior of the rays or arms of the Asterias.

Imagine, then, an animal bearing digestive tubes in its arms—the same portion serving to lodge both the organs of digestion and progression. What lessons in economy does not the study of Nature teach us! The products of digestion find an absorbent surface of great extent in the rays of the Asterias. They ought necessarily to pass rapidly from it into the circumjacent nourishing fluid.

The star-fishes are very voracious; they even attack molluscs which are covered with shells. M. Pouchet mentions having taken eighteen specimens of a species of Venus intact, each being six lines in length, from the stomach of one large Asterias which he dissected upon the shores of the Mediterranean.

It is now even said that the star-fishes eat many oysters. Ancient naturalists were not ignorant of this fact; but they believed that the star-fish waited for the moment when the bivalve would open its valves to introduce one of its rays into the opening. They imagined that

having thus put one foot into the other's domicile, they soon put the other four, and finished by reaching and devouring the savoury inhabitant of the shell. Modern observations have modified the ideas of former naturalists upon this point. In order to obtain possession of and swallow an oyster, it appears that the star-fish begins its approaches by bringing its mouth to the closed edges of the oyster-shell; this done, with the assistance of a particular liquid which its mouth secretes, it injects a few drops of an acrid or venomous liquid into the interior of the oyster-shell, which forces it to open its valves. An entrance once obtained, it is not long before it is invaded and ravaged. Professor Rymer Jones gives another explanation of the transaction. According to this naturalist the oyster is seized between the rays of his ravisher, and held under his mouth by the aid of his suckers; the Asterias then everts its stomach, according to the professor, and envelopes the entire oyster in its inmost recesses, while, doubtless, distilling a poisonous liquid. The victim is thus forced to open its shell, and becomes the prey of the enemy which envelopes it.

Whatever may be the modes of procedure employed by the star-fish, it is now clearly ascertained, however incredible the fact may at first appear, that it swallows oysters in the same manner as is practised by human beings at the oyster shop.

This little being, formed of five arms and without any other apparent member, accomplishes a work which man, unaided, is quite unable to execute—it opens an oyster without an oyster-knife. If reasoning man had no other means of nourishment than oysters, and was without a knife to open them, it is very certain that with all his genius he would be puzzled how to get at the inaccessible and savoury bivalve so obstinately closed against him.

The star-fish devours dead flesh of all kinds; their sole occupation is to feed themselves, and they keep up an incessant and active chase after all sorts of decaying animal matter. The Asterias thus perform in the bosom of the sea the same part that certain birds and insects play on shore; they are its scavengers, and feed their bodies upon the carcases of animals which, if abandoned to the action of the elements, would become a cause of infection.

In the same manner that certain animals render the air healthy, the Asterias helps, on a considerable scale, to keep the sea which shelters it in a pure and healthy state. Zoologists are not agreed upon the manner in which respiration is effected in the star-fishes. Nevertheless they think that the principal part in this phenomenon devolves upon the subcutaneous branchiæ which in each ray constitute two double series of bladders. The function of circulation is not yet

thoroughly investigated. The vascular apparatus is sufficiently developed in these Echinoderms, and appears to have for its centre an elongated canal with muscular walls, which may with some justice be honoured with the name of heart. A little ring surrounding the œsophagus, and from which issue certain delicate white cords, which are prolonged into the furrows of the arms, presents us with all that can be designated a nervous system in the star-fishes. Among organs of sense we may, perhaps, mention, as being sensible of touch, the *tentacular ambulacral feet.* The eyes are considered to be certain bright red points which are situated at the extremity of the arms almost on their under surface—a most singular position for the organs of sight. The eyes must, however, be very imperfect, for they possess no crystalline lens. Ehrenberg insists upon the existence of eyes in some species, attributing the function to those red spots, however; while Rymer Jones attributes the indications of sight-seeing sometimes observed to an extremely delicate sense of touch in the star-fishes. Professor Edward Forbes, while he admits the existence of ganglions in the nervous system to be extremely doubtful, seems, by the frequent use of the terms eyes and eyelids, to admit that the specks in question are visual organs; the weight of authority inclines therefore to Ehrenberg's view, that if not eyes in the strict sense of the term, they serve the purposes of vision, modified and adapted to the wants of the animal.

The star-fishes have distinct sexes, with individual differences; their eggs, which are round and reddish, undergo curious phases of development. They produce little worm-like creatures, covered with vibratile cilia, like the Infusoria, which swim about with great vivacity; these little creatures are subject to considerable changes. In the year 1835 M. Sars described, under the name of *Bipinnaria asterigera*, an enigmatical animal resembling a polyp from the arms at one extremity of the body, while the other terminated in a tail, furnished with two fins; but it was chiefly remarkable as having an Asterias attached to the extremity which carried the arm. He expressed an opinion, which was soon placed beyond any doubt, that this *bipinnaria* was an Asterias in its course of development. The egg becomes a sort of infusorium, the infusorium becomes a *bipinnaria*, and this produces the Asterias. In short, the Bipinnaria does not become an Asterias by any metamorphosis analogous to that so well known amongst insects—the butterfly, for example—but becomes, so to speak, the foster-mother or nurse to the Bipinnaria. The larval form is large, and it is at the cost of a very small internal rudiment of this larval form that the Asterias is developed: the Asterias robs the larval form of its stomach and intestines, and turns it into a

visceral apparatus for its own use. But the Asterias makes itself a mouth of any of the pieces most remote from the primitive mouth of the larval form. Thus the Bipinnaria divides itself; it gives its stomach and intestines, and keeps its œsophagus and mouth, and it can live several days after the Asterias is detached from it.

Can any one imagine the existence of a being with only a mouth and œsophagus, which has neither stomach nor intestines, because another animal has possessed itself of them for its own use? The study of the lower animals abounds in surprises of this kind. It is a chain of unforeseen facts, of natural impossibilities, of realised points necessarily reversing all our notions obtained in the study of beings which have a higher place in the animal scale. The history of the star-fishes would be incomplete were we to omit mentioning one of the most remarkable traits of their organisation with which naturalists are acquainted. The animals exhibit in the highest degree the vital phenomena of dismemberment and restoration, that is to say, of the faculty of reconstructing organs which they have lost. Their arms, the structure of which is so complicated, and which protect such important organs, may be destroyed by accident. The animal troubles itself little at this mutilation; if it loses an arm it disquiets it but little, another is, after a time, found to take its place. We often see in our collections of Asterias specimens wanting in symmetry because they have been taken before the new members which are in process of development have attained their definite length. Professor Rymer Jones mentions an instance of reintegration very complete and most curious. This naturalist had an isolated ray of Asterias, which he had picked up; at the end of five days he observed that four little rays and a mouth had been produced; at the end of a month the old ray was completely destroyed, and this apparently useless fragment had been replaced by a new being, quite perfect, with four little symmetrical arms. This faculty of reproducing organs, which we have noted in describing the fresh-water polyps, the sea anemones, &c., exists also in many other forms, but in none more striking than in the Asterias. But a still more startling fact remains to be mentioned—one more strange and more mysterious, for it does not belong to things physical or organic, but appears to belong to the moral world—the star-fishes commit suicide! Certain of these animals appear to escape from dangers which menace them by self-destruction. This power of putting an end to existence we find only on the highest and lowest steps of the animal scale. Man and the star-fishes have a common moral platform, and it is that of self-destruction!

Mysteries of Nature, who can sound your depths? Secrets of the moral world, what being but God has the privilege of comprehending you? A large species of star-fish (*Luidia fragillissima*), which inhabits the English seas, has this instinct of suicide to a great extent. The following account, by Professor Edward Forbes, of an attempt to capture a Luidia, gives a good illustration of its powers. "The first time that I took one of these creatures," the Professor says, "I succeeded in placing it entire in my boat. Not having seen one before, and being ignorant of its suicidal powers, I spread it out on a rowing bench, the better to admire its form and colours. On attempting to remove it for preservation, to my horror and disappointment I found only an assemblage of detached members. My conservative endeavours were all neutralised by its destructive exertions; and the animal is now badly represented in my cabinet by a discless arm and an armless disc. Next time I went to dredge at the same spot I determined not to be cheated out of my specimen a second time. I carried with me a bucket of fresh water, for which the star-fishes evince a great antipathy. As I hoped, a Luidia soon came up in the dredge—a most gorgeous specimen. As the animal does not generally break up until it is raised to the surface of the sea, I carefully and anxiously plunged my bucket to a level with the dredge's mouth, and softly introduced the Luidia into the fresh water. Whether the cold was too much for it, or the sight of the bucket was too terrific, I do not know; but in a moment it began to dissolve its corporation, and I saw its limbs escaping through every mesh of the dredge. In my despair I seized the largest piece, and brought up the extremity of an arm with its terminal eye, the spinous eyelid of which opened and closed with something exceedingly like a wink of derision."

The mind remains confounded before such spectacles; and we can only say, with Mallebranche, "It is well to comprehend clearly that there are some things which are absolutely incomprehensible."

This is doubtless the reason that in collections of natural history we rarely find star-fishes, and especially species of Luidia, entire; the moment the animal is seized by fisherman or amateur, in its terror or despair it breaks itself up into small fragments. To preserve them whole they must be killed suddenly, before they have time to be aware of their danger. For this purpose, the moment they are drawn from the sea they must be plunged into a bucket of cold fresh water; this saltless liquid is instant death to these creatures, which in this condition perish suddenly before they have time to mutilate themselves. The star-fish is a curious ornament in our natural history

collections, but in their dried state they represent very imperfectly the elegance and particular grace of this curious type of beings. To understand the star-fishes, they must be seen in an aquarium, where we can admire the form, figure, movements, and manners of these marvellous beings.

The Asterias are the planets of the sea. It may be said that heaven, reflected during the night on the silvery surface of the ocean, let fall some of those stars into its depths which decorate the resplendent vault.

CRINOÏDEÆ.

We quoted the maxim of Linnæus in the earlier pages of this volume, that Nature makes no leaps. Nature proceeds by means of insensible transitions, rising by degrees from one organic form to another. Most of the animals hitherto described are immovably fixed to some solid object; at least, such is their condition in the adult state. We are about to describe Echinoderms free of all fetters; animals "which walk in their strength and liberty" at one time of their existence, while at others they are fixed and stationary.

The Crinoïdæ, the first family of Echinoderms, are mostly attached to marine rocks by a sort of root, having a long flexible stem, which enables them to execute movements in the circle limited only by the length of this stem, just as the ox or goat in our paddocks is confined by its tether to the space circumscribed by the length of its rope.

Let the reader picture to himself a star-fish borne upon the summit of a flexible stem firmly rooted in the soil, and he has a general idea of the form of some of the Echinoderms which compose the family of the Crinoïdeæ. Naturalists of the seventeenth century bestowed the name of *stone lilies* on these curious products. This rather poetical name proves that the conformation of these creatures had at an early period attracted observation, presenting the naturalist with the most curious of his lessons. The encrinites raise up, as from the dead, a whole world buried in the abyss of the past. At the present time only a few genera of these Echinoderms exist, whilst in the early ages of the world the ocean must have swarmed with them. Crinoids abounded in the seas during the transition and secondary epoch. It was one of the most numerous of the families which inhabited the salt waters of the ancient world. In traversing some parts of France, we tread under our feet myriads of these beings, whose calcareous remains form vast beds of rock. The Encrinites gradually disappeared from the ancient seas; their species were

diminished as the globe became older or modified in its conditions, so that at the present time only a few types remain in our seas—such as the genera *Comatula*, *Pentacrinus*, the Medusa's-head of the Antilles, *Holopus*, and *Rhizocrinus* of the deep sea—all of them probably destined soon to disappear, carrying with them the last reminiscence of the zoological races of the Echinoderms of the ancient world; and here lies the real interest which the Crinoïdeæ presents to the thinking man. The Encrinites most common in the fossil state are *Pentacrinus fasciculosus*, belonging to the lias; *Apiocrinus rotundus*, which is found in the oolite or jurassic rocks; and *Encrinus liliformis*, which appertains to the triassic period. These three fixed Crinoids seem to have existed in great numbers during an early age of the world—namely, the Silurian period. They attained their maximum of development during the Devonian age, after which they begin to decrease. According to M. d'Orbigny, there are thirty-nine genera found in the palæozoic rocks, two in the triassic, seven in the jurassic, five in the cretaceous, and only one in the tertiary strata. Of all these genera but two or three are found in the modern epoch to represent the varied forms of these the first inhabitants of the seas.

The free Crinoïdeæ, that is those not rooted to the soil by a stem, of which the *Comatula* may be considered the type, only appeared at a later period. They are absent in the palæozoic and triassic rocks, but appear to have attained their maximum of development in the jurassic period.

The numerous fossilised remains of these curious creatures which abound in different rocks, attracted the attention of learned men at an early period. The Encrinites were among the earliest objects of scientific description. As early as the sixteenth century the celebrated mineralogist, George Agricola, mentions them under the names of *Entrochites*, *Trochites*, and *Astroïtes*. At the same time, and since that epoch, the Crinoïdeæ, which we know by the name of stone lilies, and which characterise the *Muschelkalk* rocks, have been known under the name of Encrinus, from εν, stone, and κρίνον, a lily.

During the eighteenth century the works upon the Crinoïdeæ were very numerous, though not very correct. They sometimes reported these organic remains to be vegetable; sometimes they were beings allied to the star-fishes; at others they were the vertebral column of fishes. Towards the year 1761, however, Guettard, one of the most learned naturalists of his time, understood the real nature of these productions. He had occasion to examine a recent Encrinus sent from Martinique under the name of *Sea-Palm*, which was in reality

Pentacrinus caput Medusæ.

The comparison of the living individual with the fossil fragments described by his predecessors, and of which he had specimens in his collections, enabled him to ascertain the real origin of the fossil Encrinoïdeæ. The beautiful fragment of this recent form which still exists in the Museum of Natural History at Paris was long considered unique, but it is now known that many others exist in the different museums of Europe and America. Since that date the Crinoïdeæ have been examined and described by observers such as Miller, Forbes, d'Orbigny, Agassiz, Sars, Pictet, Major Austin, and by Carpenter and Wyville Thomson.

Among the species of fixed Crinoïdeæ actually living are *Pentacrinus caput Medusæ* (Fig. 106) and *Rhizocrinus lofotensis.* These curious Echinoderms resemble a flower borne upon a stem, which terminates in an organ called the calyx, which is, properly speaking, the body of the animal. Arms, more or less branching, spring from this calyx, their ramifications, so formed, consisting of many pieces articulated to each other. The calyx is supported by a stem, varying in height, formed of pieces secreted by the living tissues which surround them. The articulations

Fig. 106.—Pentacrinus caput Medusæ (Müller).

of this stem are usually very numerous, cylindrical, and present a series of rays striated upon their articulated faces. In *Pentacrinus* they are

Fig. 107.—Pentacrinus europæus (Thompson).

prismatic and pentagonal; that is, they present five projecting angles, and on their articulated face a star with five branches, or, better still,

a rose with five petals. At the base of the stem of this animal-plant, in many of the Crinoïdeæ, we find a sort of spreading root, which is implanted in the rocks, and is capable of growing by itself, and of nourishing the stem.

The root and stem of the fixed Encrinites seem to indicate that the animal can only live with the head erect. Their normal condition is thus quite different from that of any other of the Echinoderms, almost all of which keep their mouths invariably directed downwards.

Pentacrinus and *Rhizocrinus* are chiefly found on rocky beds, or in the midst of banks of corals, at great depths. There, firmly fixed by their roots, their long stems raise themselves vertically; then, with expanded calyx and long-spreading arms, they wait for the prey which passes within their reach in order to seize it.

The *Pentacrinus caput Medusæ* has, as we have said, been fished up from great depths in the Antilles. It is borne upon a stem of from eighteen to twenty inches in height, terminating in long movable arms, the internal surface of which bears the ambulacral feet. In the middle of the arms is a mouth, and at the side the orifice for the expulsion of the digested residuum.

The Crinoïdeæ are not, however, all like the two species which have been referred to. There is an entire section of the animals belonging to this class, namely, the *Comatulidæ*, which are fixed in their early days, but separate themselves from the rooted stem in their adult age, and, throwing off the bonds imposed in their youth, live freely, swimming through the water, or clinging to mussel or oyster banks. Species of the genus Comatula are found in the seas of both hemispheres. Their bodies are flat—large calcareous plates form a cuirass upon their backs—presenting, besides, cirri composed of numerous curling joints, the last of which terminates in a hook. The ventral surface presents two orifices: the one in the centre corresponding to a mouth, the other evidently intended for the discharge of the products of digestion. This animal is provided with five arms, which diverge directly from the centre plate or cuirass. The branches of these arms have a double row of ambulacral feet, in the centre of which is the ambulacral groove, properly so-called. The feet are clothed with vibratile cilia over their whole surface. These cilia guide the current which drives the substances on which the animal feeds—such as the organic spores of sea-weeds and microscopical animalcules floating in the sea—towards its mouth.

The movements of these curious creatures are very slow, their only object being to catch the bodies of animals and marine plants, or, by extending or contracting their arms, to feel their way through

the water to some new locality. Sometimes, also, in order to change their feeding-ground, the Comatula abandon the submarine forests herbage, and sea-wracks, and float through the water, moving their arms with considerable rapidity in search of a new station.

The Mediterranean Comatula (Fig. 108) is largely diffused around

Fig. 108.—Comatula mediterranea (Lamarck), natural size.

the shores of the Mediterranean, and on our own coasts. Its spreading arms extend to three or four inches; its colour is purple, shaded and spotted with white upon the ventral surface.

Were a traveller to tell us that he had seen animals drop their eggs upon masses of stone; that these eggs, after executing certain progressive evolutions, finally became individuals in all respects unlike their parents, and attached themselves to the stones by a root

like any flower of the fields, or to the mother stem like the branch of a tree, until in due course they attained the almost adult state, when the flexible stem which holds them fixed either to the soil or parent stem breaks, and the animal, now free, launches itself into the liquid medium, now resembling its parent form, and goes to live a proper and independent existence; in listening to a recital so opposed in appearance to the ordinary laws of Nature, we should be inclined to tax the narrator of such incredible facts with error or folly. Nevertheless, all these facts are now perfectly established. The being which presents these marvels has nothing of the fabulous about it; it is the *Comatula mediterranea.*

In the Pentacrinoid stage of Comatula (Fig. 107), the presence of a digestive apparatus has been distinctly traced. It is a sort of irregular sac, with a central mouth on the upper surface, and another orifice situated at a little distance from the mouth, and evidently intended as an outlet for the products of digestion. The arms of these creatures, which are spreading or folded up, according to their wants, are provided with ambulacral feet, which, serving at once as organs of absorption and having vibratile cilia, are at the same time organs of respiration. Such are these curious beings: they occupy a sort of middle or transition state between animals permanently fixed to some spot and those capable of motion, representing in our own times the last remains of extinct generations. Every specimen of the Crinoïdeæ furnished with arms presents evidence of their reproduction or re-integration.

Asteriadæ or Star-fishes.

In walking on the sea-shore at low tide, your eyes have often seen the animal which commonly and sometimes scientifically bears the name of star-fish half-buried in the sand. It is so regular and geometrical in its form that it has more the appearance of being the production of man's hand than of being a creature which breathes and moves. The divine Geometrician who created it never realised a creature more regularly finished in shape or more perfectly harmonious in symmetry.

Ophiuridæ.

The Ophiuridæ are thus named from two Greek words (ὄφις, a serpent, and οὐρὰ, a tail), from their fancied resemblance to the tail of a serpent. These Echinoderms are met with in almost every sea, both in those of the tropical and temperate regions; they are

very common on every shore, and have been remarked by fishermen from the earliest times on account of their singular form, the disposition of their arms, which resemble the tail of a lizard, and by the singularity of their movements. The general characteristics of this remarkable group of Echinodermata, as described by Dujardin and Hupé, are as follows :—They are radiate marine animals creeping at the bottom of the sea or upon marine plants. In form they present a sort of coriaceous disc, which is either bare or covered with scales, which contains all the viscera, and has articulated to it five very flexible simple or branching arms, each supported by a series of calcareous internal pieces ; they are naked or covered with granules, scales, or spines. The mouth is situated in the middle of the lower surface of the disc, and opens directly into a stomach which is in the shape of a sac ; it is circumscribed by five re-entering angles corresponding with the intervals between the arms, having a series of calcareous pieces, which perform the function of foot jaws. The mouth is prolonged by five longitudinal clefts, which correspond to the arms, and are garnished with papillæ or calcareous pieces. A series of calcareous pieces, somewhat rib-shaped, spring from the extremity of each of these clefts, which occupy all the interior of the arms, having a furrow in the middle of the ventral surface for the reception of a nutritive vessel ; and laterally between their expansions are certain openings, from whence issue the ambulacral feet ; the visceral cavity opens by one or two clefts on the ventral surface of each side of the base of the arms.

The Ophiuridæ move themselves by briskly contracting their arms so as to produce a succession of undulations analogous to those by which a serpent creeps along. Some of these Echinoderms are rather active ; but others attach themselves by their arms to the branches of certain Gorgonidæ, and remain immovable for a considerable time, waiting their prey somewhat like a spider in the midst of his web.

The family of Ophiuridæ is divided into two great sections : that of the Ophiurinæ, which comprehends several genera, amongst others that which gives its name to the family; and that of the Euryalinæ.

The family of Ophiurinæ forms a group distinguished by their five simple, articulated, very mobile, and non-ramified arms, each of which is attached to a small disc or shield plate, with flexible thread-like cirri between the rays. The genus *Ophiura* is very common, and has been known from very early times in European seas. The species are often of a greenish colour, with transverse bands, which become more obscure upon the arms as the distance from the disc increases.

This disc is from six-eighths to seven-eighths of an inch in size, the upper part covered with unequal plates, in shape like tiles; the arms are four times the length of the diameter of the disc, very slender and tapering. The Ophiuroid to which Lamarck gave the name of

Fig. 109.—Ophiocoma Riisei (Lutken), natural size.

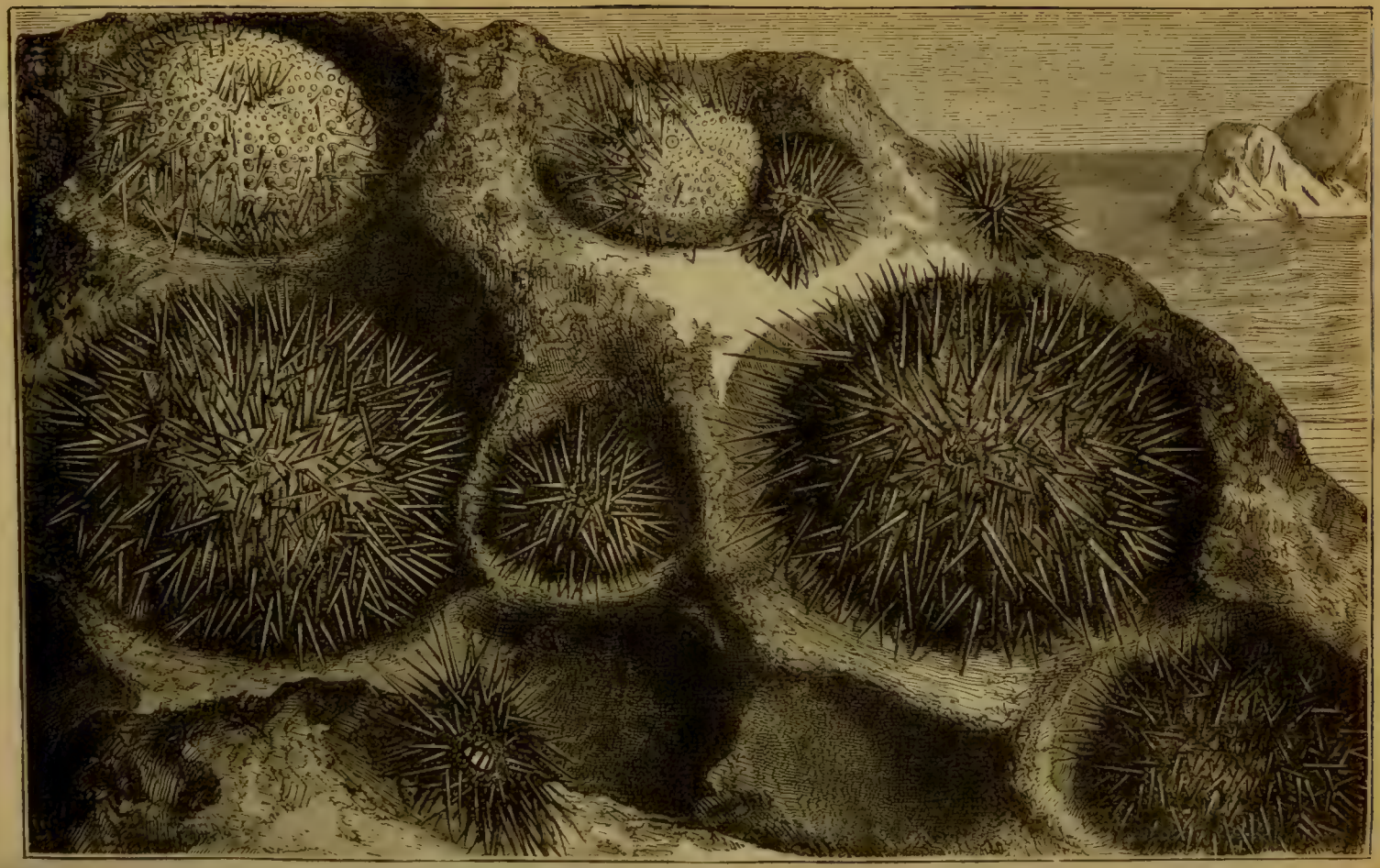
Ophiura fragilis has now its place in the genus *Ophiothrix*, the specific name indicating a peculiarity of structure in all these small creatures derived from their fragile formation. In short, these beings have so little consistency, that many of them crumble as it were under the touch, and become reduced to pulp under the slightest pressure. In Fig. 109 we give the representation of an Ophiuroid of the natural

size, which Lutken has since called *Ophiocoma Riisei.* This Echinoderm, which lives in the seas of the Antilles, is furnished with five very flexible rays, which are armed with from three to four rows of spines, those on the upper part of the body being very hard

Fig. 110.—Asterophyton verrucosum (Lamarck).

ones; the body and arms of this creature are of reddish brown, streaked with a great number of little white lines.

The principal type of the Euryalinæ is the curious and complex *Asterophyton verrucosum* of Lamarck. This section includes the Ophiuroids, remarkable for the extremely complicated development of their arms; the very multiplied ramifications of these, towards the extremities, being again divided into many thousand very slender appendages, the principal use of which is doubtless locomotion, but



VIII.—Sea Urchins lodged in the rocks they have excavated.

at the same time they constitute a series of living thread-like weapons which seem intended to seize and close upon the animals which serve as prey to these little flesh-eaters. The *Asterophyton verrucosum*, which is represented in Fig. 110, is yellowish; its disc about four inches, its arms sixteen to eighteen; it inhabits the Indian Ocean. Another species, *A. arborescens*, is met with on the coasts of Sicily and other parts of the Mediterranean. Nothing can be

Fig. 111.—Acrocladia mamillata (Lamarck), natural size.

more elegant than these animated discs, which resemble nothing so much as a delicate piece of lace—a piece of living lace moving in delicate festoons in the bosom of the ocean.

ECHINIDÆ.

The singular shape of the Echinidæ, or Sea-urchins (PLATE VIII.), and the spiny armature with which their bodies are covered, has in all ages attracted the attention of naturalists. Aristotle applied to them the name ἐχῖνος, which signifies urchin. When, however, one sees the body of one of these animals thrown on the sea-shore, it is difficult,

at first, to find a reason for this designation. The corona or body of the sea-urchin is furnished with different kinds of spines. It forms a shell, nearly spherical, empty in the interior, its surface presenting reliefs remarkable for their regularity. In order to see the urchin with its spines it is necessary to seize it as it lives, in the water at the bottom of the sea, where it rolls and moves its little prickly mass; it is then only that the real urchin—the prickly sea-urchin—is to be seen, bristling with prickles, and strongly resembling, to compare the physical with the mental, those amiable mortals whose character is so well depicted in the saying, "Whom they rub they prick."

In his book on "The Sea," Michelet puts the following conversation into the mouth of a sea-urchin:—

"I am born without ambition," says the modest Echinoderm; "I ask for none of the brilliant gifts possessed by those gentlemen the molluscs. I would neither make mother-of-pearl nor pearls; I have no wish for brilliant colours, a luxury which would point me out; still less do I desire the grace of your giddy Medusas, the waving charm of whose flaming locks attracts observation and exposes one to shipwreck. Oh, mother! I wish for one thing only: *to be*—to be without these exterior and compromising appendages; to be thickset, strong, and round, for that is the shape in which I should be the least exposed; in short, to be a centralised being. I have very little instinct for travel. To roll sometimes from the surface to the bottom of the sea is enough of travel for me. Glued firmly to my rock, I could there solve the problem, the solution of which your future favourite, man, seeks for in vain—that of safety. To strictly exclude enemies and admit all friends, especially water, air, and light, would, I know, cost me some labour and constant effort. Covered with movable spines, enemies will avoid me. Now, bristling like a bear, they call me an urchin."

Let us now look a little more closely at the general structure of the sea-urchin—in zoological language, Echinus.

The body of the sea-urchin is globular in form, slightly egg-shaped, or of a disc slightly swollen. It consists essentially of an exterior shell, or solid corona covered with spines, and invested in a delicate membrane furnished with vibratile cilia. This corona is formed of an assemblage of contiguous polygonal plates, adhering together by their edges. Their arrangement is such that the test or shell may be divided into vertical zones, each springing from a central point on the summit, and terminating at a point of the spheroid diametrically opposite—namely, the circumference of the buccal orifice. These vertical zones are of two kinds, some larger and others straighter,

each zone consisting of a double row of plates, the first charged with movable spines, the second pierced with holes disposed in regular longitudinal series, from which emerge the ambulacral feet, which, as we shall see presently, serve as organs of locomotion to the animal. When armed with these bristling spines, the sea-urchins resemble the hedge-hogs; but when the spines are rubbed off, they look very much like a melon or an egg, to which their shape and calcareous nature have sometimes led to their being compared by the vulgar as well as by the learned. We shall give a tolerably exact idea of the two different aspects which the corona of the urchin presents when the spines are still on and when they have been removed, by reference to

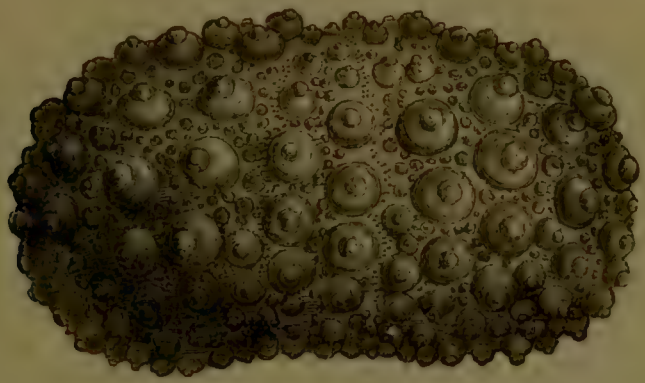


Fig. 112.—Acrocladia mamillata. Sea Urchin, without spines, natural size.

Fig. 111 (*Acrocladia mamillata*), which represents the animal bristling with spines, and Fig. 112, in which the same species is represented after death, when these weapons of defence have been rubbed off—and how complicated these organs of defence must be! It has been calculated that more than ten thousand pieces, each admirably arranged and united, enter into the composition of the shell of the sea-urchin. To abbreviate slightly Gosse's description of that wonderful piece of mechanism, the sea-urchin: "A globular hollow box has to be made, of some three inches in diameter, the walls of which shall be scarcely thicker than a wafer, formed of unyielding limestone, yet fitted to hold the soft tender parts of an animal which quite fills the cavity at all ages. But in infancy the animal is not so big as a pea, and it has to attain its adult dimensions. The box is never to be cast off or renewed; the same box must hold the infant and the veteran urchin. The limestone can only increase in size by being deposited. Now the vascular tissues

are within, and the particles they deposit must be on the interior walls. To thicken the walls from within leaves less room in the cavity; but what is wanted is *more* room, ever more and more. The growing animal feels its tissues swelling day by day, by the assimilation of food. Its cry is, 'Give me space! a larger house, or I die!' How is this problem solved? Ah! there is no difficulty. The inexhaustible wisdom of the Creator has a beautiful contrivance for the emergency. The box is not made in one piece, nor in ten, nor a hundred. Six hundred distinct pieces go to make up the hollow case, all accurately fitted together, so that the perfect symmetry of the outline remains unbroken; and yet, thin as their substance is, they retain their relative positions with unchanging exactness, and the slight brittle box retains all requisite strength and firmness, for each of these pieces is enveloped by a layer of living flesh; a vascular tissue passes up between the joints, where one meets another, and spreads itself over the whole exterior surface." This being so, the glands of the investing tissue secrete lime from the sea water, and deposit it after a determinate and orderly pattern on every part of the surface. Thus the inner face, the outer face, and each side and angle of the polyhedron, grow together, and the form characteristic of the individual is maintained with immutable mathematical precision.

The dimensions and shape of the spines are very variable. In certain Echinidæ they are three or four times the diameter of the body. In the common sea-urchin, properly so called, they are only three-fourths or four-fifths that diameter. They sometimes resemble short bristles. These defensive weapons have tubercles for supports, which are arranged on the surface of the animal with perfect regularity. At the base they present a small head separated by compression. This head is hollow on its lower face, presenting a cavity adapted to a tubercle of the shell. Each of the spines, notwithstanding its extreme minuteness, is put in action by a muscular apparatus.

In the spines and ambulacral feet we see the external organs of the Echinidæ. The former are instruments of defence; the latter, strange as it may appear, serve them to walk with. When it is considered that each of these spines is put in motion by several muscles, it is impossible to repress our wonder and surprise at the prodigious number of organs brought into action in the sea-urchin. More than 1,200 spines have been counted upon the shell of *Echinus esculentus*, a representation of which is given in Fig. 113. If we add to this first supply of spines other smaller and in some sort accessary spines, we shall arrive at a total of 3,000 prickles. Each sea-urchin thus bears as many weapons as ten squadrons of lancers. When it

is considered, further, that in each series of ambulacral feet there exist not less than 100, you will have a total of 4,000 visible appendages upon the body of an animal of very small dimensions. If it is considered, finally, that no shell exists more admirably symmetrical, elegant, or more highly ornamental than the corona of the

Fig. 113.—Echinus esculentus (Lamarck), natural size.

sea-urchin, it will readily be admitted that Nature has been most prodigal in her gifts to one of the humblest beings in creation—a creature which passes its existence in crawling in obscurity at the bottom of the sea. What elegance of form, eternally hidden from the eyes of man, sleeps under the heavy mass of water; and yet man imagines that everything in Nature has been created for his use and for his glory!

M. Hupé records a somewhat curious observation in connection with the spines which serve as a means of defence to the Echinidæ. He found a small mollusc, of the genus *Stilifera*, which had sought shelter in *Loxocidaris imperialis*, a sea-urchin, native of Australia; in a word, the interior of one of these prickles had been hollowed and enlarged so as to serve as a retreat for this improvised guest.

What unexpected facts does the study of animals present! Nature has bestowed a protecting armour upon one little being; another still smaller animal discovers this, and places itself for shelter under the protection of one of these levelled bayonets!

Now let us see by what organic mechanism the sea-urchin contrives to transport itself and walk. The ambulacral feet are hollow internally, and, as we have said, are provided with small muscles. By the influx of liquid which they enclose they become inflated throughout all their length, in such a manner that they can attach themselves to any solid body, at the will of the animal, by means of their terminal suckers. Frédol, in "Le Monde de la Mer," thus explains the sea-urchin's mode of progression. "Let us imagine," he says, "one of these creatures to be at rest; all its spines are immovable, and all its feet repose within the shell; some of these involuntarily are protruded; they extend themselves and feel the ground all round them: others follow, but the animal is firmly fixed. If it wishes for change of place, the anterior feet contract themselves, whilst the hinder ones loosen their hold, and the shell is carried forward. The sea-urchin can thus advance with ease, and even rapidity. During his progression the suckers are only slightly aided by the spines. It can travel either on its back or stomach. Whatever their posture, they have always a certain number of feet, which carry them, and suckers, with which they attach themselves. In certain circumstances the animal walks by turning upon itself, like a wheel in motion."

Nothing is more curious than to see a sea-urchin walk upon smooth sand. But for its colour, it might be mistaken for a chestnut with its bristling envelope, the spines serving as feet to put the little round prickly mass in motion. They have even been observed to make very considerable progress under these circumstances.

One of the most singular organs of the sea-urchin is its mouth. It is most curious. Placed underneath the body it occupies the centre of a soft space invested with a thick resisting membrane: it opens and shuts incessantly, showing five sharp teeth (Fig. 114) projecting from the surface, the edges meeting at a point, as repre-

sented here, supported and protected by a very complicated framework, which has received the name of Aristotle's Lantern (Fig. 115). Fig. 114 represents *Echinus lividus*, with all its spines removed; the other shows the masticatory organs, that is to say, Aristotle's Lantern. To give the reader another idea of the buccal organ in the sea-urchins let him glance at a flattened form from the southern seas, *Clypeaster rosaceus*, represented in Figs. 116 and 117, an outline of the entire animal.

Fig. 114.—Buccal armature of Echinus lividus.

The shape of *Clypeaster rosaceus* is oval, straighter in front, and thick and rounded at the edges. It is more common and more largely distributed than perhaps any other allied species, and it is supplied with four or six rows of ambulacral feet.

It is not easy to understand why the dental framework of the

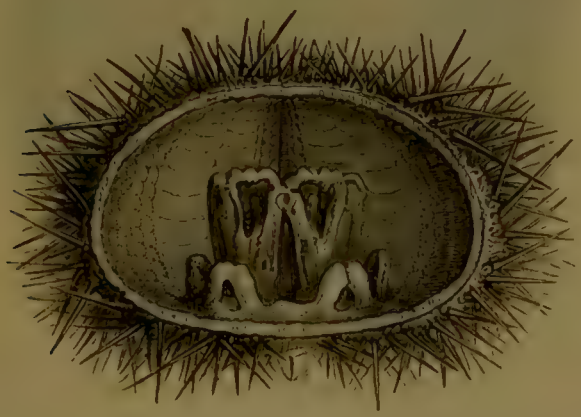


Fig. 115.—Masticating apparatus of Echinus lividus.

sea-urchin has been called Aristotle's Lantern, for this formidable apparatus resembles the front view of a battery of cannon more than a lantern. It consists of a series of pieces designated by the names of compass, scythe, pyramid, and plumula, which it would serve no useful purpose to describe in detail here.

We have said that the mouth of the sea-urchin is quite out of

proportion to its size, and the teeth are of proportionate dimensions. As these project from a very formidable mouth, one can easily be assured of the sharpness of their extremities by intruding his fingers into them. In fact, it is necessary that these organs should be singularly powerful, because, as we shall see farther on, the sea-urchin possibly makes incisions in the solid rock with them, and hollows out shelter for himself. The strong and sharp teeth grow at the base in

Fig. 216.—Clypeaster rosaceus (Lamarck).

proportion as they are used at the points, as is the case with some of the rodent mammals. By this means they are always sharp and in good condition. Five groups of powerful muscles are used to work these terrible grinders.

To this formidable mouth is attached an œsophagus or gullet, and an intestine which extends along the interior walls of the corona, describing the circumference of its principal contour.

The food of the Echinidæ is still imperfectly known; nevertheless,

from the presence of shells, fragments of corals, crustaceans, and even other Echinodermata in their intestinal tube, it is to be inferred that a certain number of them at least are carnivores, or flesh-eaters, while others are supposed on the same evidence to be vegetarians. The organs of respiration of the Echinidæ appear to be certain flattened vesicles in the form of very delicate laminæ, which adhere to the internal surface of the walls of the body, and float freely in the

Fig. 117.—Skeleton and Masticating Apparatus of Clypeaster rosaceus.

liquid with which the visceral cavity is filled. These organs, known as the internal *branchiæ*, are in communication with the central canal and ambulacral tubes. The heart is spindle-shaped, tapering above, swelling out below. There are two distinct vascular systems, one intestinal, the other cutaneous.

The nervous system consists of a ring, which surrounds the gullet, and is placed at a short distance from the mouth. In this ring the nervous trunks have their origin. In reference to the senses, we may observe that that of touch is highly developed. Certain forms called

Pedicellaria, which surround the mouth, and are fashioned like nippers, are also to be met with. They appear to be altogether destitute of organs of sight. It has sometimes been argued that five red points at the summit of the dorsal surface are eyes; but this opinion has not been maintained, nor has any crystalline lens been found in these spots to justify it. Captain de Condé states that he examined a sea-urchin with long spines in a pool of water, which he tried to catch, when he saw it direct itself towards his hand, all its spines being erect. Surprised at this manœuvre, he tried to seize it from another quarter; its spines were instantly directed to the other side. "I have thought from that time that the urchin saw me, and prepared to resist my attack. In order, however, to satisfy myself whether or not the movement in the water caused by my approach might have produced the effect described, I repeated the experiment with greater caution. But the creature always directed its spines in the direction of the object which threatened it, whether it was in the water or out of it." He satisfied himself that these animals certainly could see, and that their spines served them as a means of defence.

These wonderful spines, this calcareous envelope, this armour so marvellously studded, with which Nature has so bountifully provided the Echinidæ, appear to have been insufficient, inasmuch as these very spines, in order to secure the safety of the animal, are gifted with the power of hollowing a dwelling for themselves out of solid rocks of the hardest material, such as granite and sandstone. They fix themselves to its surface by means of their tentacles; they make an incision by means of their strong teeth, removing the débris with their spines as fast as it is produced. When the hole is large enough, they entrench themselves in it, with their spines like threatening pikes levelled to protect them from all external assaults. To M. Caillaud, the conservator of the Museum of Nantes, we are indebted for an excellent account of the manner in which this buccal apparatus is made to operate. "The Lantern of Aristotle," says this author, "forms the mandibulary apparatus; the teeth are five in number, and they may as well receive the denomination of a series of saws and picks as of teeth, for they are surprisingly adapted to the excavation of holes in the hardest rock. These five picks are about the eighth of an inch long, and they serve the sea-urchin at once as masticators and excavating implements. In opening the jaws, these five teeth strike the stone forcibly rather than scrape it." This property of hollowing their dwelling out of the solid rock appears, however, to belong to only a small number of the Echinidæ; most of them are

content to hide themselves under the stones, while the species having the spines slender and the shell very thin bury themselves in the sand, with which they cover themselves entirely, leaving only a small hole to breathe through. The species of the genus *Spatangus*, which is furnished with short thick-set spines on the under side of its body, which spread out at their extremities like the channel of a spoon, proceeds with its mining operations as follows, according to Mr. Jonathan Franklin :—"Figure to yourself, reader, the animal on the sea-shore. He commences his operations by turning the lower spines in such a manner as to form a hollow in the sand-bank, in which he sinks by his own weight; but as he sinks, a great number of the spines are brought into action, throwing up the sand with increased activity, while the sand thrown up, returning again, soon covers the body of the worker, and it has soon buried itself beneath the surface. In this situation the long hair-like spines situated upon the back begin to play their part; they prevent the sand from entirely covering the animal, by forming a little round hole, through which water is introduced to the mouth and respiratory organs." The hiding-place of the sea-urchin is, however, easily detected in the sand by the hole thus arranged for the respiration of the animal, and the fishermen think they can predict storms according to the depth of the hole.

The Echinidæ are reproduced by eggs, which are red and of almost microscopical dimensions. As it issues from the egg the larval form has the appearance of a very minute Infusorium. It is not at once converted into the perfect animal, but undergoes a certain metamorphosis, analogous to that of the caterpillar into the butterfly. But, as we have already stated in treating of the Asteridæ, it produces, at a certain stage, by some sort of internal process of germination, a sea-urchin, which, being at first only an organ of the larval form, begins to live an independent life when the nursing larval form has destroyed itself. The manner in which the sea-urchin unfolds itself at the expense of the larval form is quite analogous to that which is presented in the case of the Asterias, it is another case of alternate generation, of which our space does not permit us to give even a general outline.

Sea-urchins are found in every sea; they dwell in sandy bottoms, and sometimes upon rocky ground. They are caught with wooden pincers when in shallow water; when found at the water's edge they may be taken by a gloved hand.

The sea-urchin, like the crab, which it also resembles in taste, becomes red when boiled; only certain species are comestible,

however. In Corsica and Algeria the melon-shaped urchin (*Echinus melo*) is much esteemed. In Naples and in the French ports of the Channel the *Echinus lividus* is eaten. In Provence the common sea-urchin (*Echinus esculentus* and *Echinus granulosus*) are the favourites.

Sea-urchins are also eaten raw, like oysters. They are cut in four parts, and the flesh taken out with a spoon; they are sometimes, but more rarely, dressed by boiling, and eaten from the shell like an egg, using long sippets of bread, hence the name of sea-eggs, which they bear in many countries.

Sea-eggs were a choice dish upon the tables of the Greeks and Romans; they were then served up with vinegar or hydromel, with the addition of mint or parsley. When Lentulus feasted the priest of Mars—the Flamen Martialis—this formed the first dish at supper. Sea-eggs also appeared at the marriage feast of the goddess Hebe. "Afterwards," says the poet, "came crabs and sea-urchins, which do not swim in the sea, but content themselves by travelling on the sandy shore." For my own part, I have only once partaken of sea-urchin, and it appeared to me to be food fit for the gods; but perhaps the circumstances sufficiently explain this dash of culinary enthusiasm. The Reserve Restaurant at Marseilles has not always been the vast stone edifice we now behold, backed majestically by the mountain, and fronting the sea on the promenade of the Corniche du Prado; in 1845 it rose quite at the entrance of the port, a small glass cage, suspended as it were by a magic thread between the heavens and the sea. From this aërial dwelling, overhanging with unheard-of audacity the waters which surrounded it on all sides, we gazed on the most wonderful prospect in the world, and reposed ourselves, while enjoying this intoxicating scene, during which the ships were continually entering the port, passing under our very feet. It was in this enchanted palace that sea-urchins were served up, supported by the traditional bouillabaise.

As I have said, it appeared to me delicious. Was it the Provençal dish, the savoury bouillabaise, which contributed to my appreciation of the humble sea-urchin of the Mediterranean? Was not the marvellous view which I enjoyed from the heights of my empyreum of glass the indirect cause of it? This is a tender and charming problem which I love to leave floating in the clouds, half evanescent, of my youthful recollections.

HOLOTHUROIDEÆ.

The ignorant, like you and I, call the Holothurias Sea-cucumbers, and perhaps, for two reasons, they are not far wrong. The term

"sea-cucumber" expresses with wonderful exactness the shape of the animal, and its habitation, the sea; and, again, it would puzzle the most learned to explain the word *Holothuria*. The body of this strange creature presents the form of an elongated and worm-like cylinder; its dimensions are so variable that, while some species are only an inch or two in length, others attain thirty and even forty inches. In general, the skin of the Holothuria is thick and leathery; it is provided with muscles, and is armed occasionally with small projecting hooks or anchors, which enable the creature to hang for a few seconds on to foreign bodies. From this coriaceous envelope issue ambulacral feet analogous to those described in the sea-urchins and sea-stars.

When we open a Holothuria we find nearly the whole internal cavity occupied with little white tubes. We know that the fabulous cucumber spoken of in the "Arabian Nights" was stuffed with pearls by the talking-bird. With our poor animal this, alas! is not so. These are no pearls, but simple prosaic cæcal tubes. The mouth opens at the extremity of the body; it forms a sort of funnel, and is surrounded like a crown, with an elegant circle of tentacula. In the living animal, when it feels itself in security, these tentacles expand themselves like the corolla of a flower. When the fisherman seizes a Holothuria in the water this crown of tentacles ceases to appear, for the animal has the power of withdrawing it quite suddenly, and now it resembles nothing so much as a common leech. If, however, it is preserved in fresh sea-water, and left in peace—if we treat it, in short, with the regard due to its elegant crown of tentacles—this elegant ornament will be expanded in all its glory. Immediately below the mouth is a muscular pharynx, which is contained in a long intestine, with many convolutions, which terminate in the posterior part of the body in an orifice whence is thrown from time to time a little jet of water. The terminal portion of the intestinal canal in these animals is enlarged, introducing us to a system of numerous tubes which branch off into the visceral cavity, receiving the water from without while breathing by its posterior extremity; the animal can at will fill this reservoir or eject the water, and it is by these alternate movements of inspiration and its reverse that it renews the oxygen necessary for respiration. The circulation appears to form a complete circle, there being no heart or central organ; but a ring round the gullet, from which issue five principal nervous chords, represents the nervous system.

The Holothuria are of separate sexes, and they differ from the sea-urchins and star-fishes in this: that the ova are developed in many

cases directly into forms like those from which they sprung. The bodies of certain species are lubricated by an acrid and corrosive fluid: thus *H. oceania*, described by Lesson, which is about forty

Fig. 118.—Holothuria lutea (Quoy and Galmard).

inches in length, secretes at the surface of its body an irritating fluid, which produces an intolerable itching in the finger which touches it. Nor can the inhabitants of the South Sea Islands look at it without loathing. Fig. 118 represents *H. lutea*, or the *Stichopus luteus* of Brandt, who describes as its distinctive character three rows of ambulacral feet on the ventral surface.

We have spoken of the strange suicidal tendency of the sea-stars: the Holothuria exhibit the same phenomena, but, having no brittle envelope like the sea-stars, it cannot break itself into bits in the presence of its disconcerted enemy; but kills itself in this manner: having some cause of grief and trouble—such, for instance, as the attack of an enemy or the pursuit of some fisherman—by a sudden and unexpected movement it ejects its teeth, its stomach, its digestive apparatus, and reduces itself to a simple empty membranous sac, with an unfurnished mouth; and, as a singular fact, this empty sac still shrinks and contracts in the hand which grasps it. It must be admitted that this is a strange mode of evading its enemies: the soldier rarely throws his arms away in the moment of danger! But the Holothuria possesses a wonderful recuperative power also; and it is probably quite conscious, when it thus empties itself to disappoint its pursuer, that it can promptly replace the organs which it has voluntarily parted with.

Dr. Johnston relates that he had forgotten for some days to supply a Holothuria with a change of water. The creature, in consequence, ejected its tentacles, its buccal apparatus, digestive tubes, and a portion of its ovaries. Still it was not dead, but was sensible to the least movement, and lived to reproduce all its organs anew.

The habits of these animals are but little known. They inhabit the seas, and are spread over every latitude. Their very limited movements consist in a kind of reptation or crawling motion, produced by the undulations of their bodies or by the contractions of their feet. Some few species, however, can glide along very swiftly and gracefully. Holothuria are generally found in the act of creeping upon stones or on portions of submarine rock, but always in sheltered places, for they appear to dread the full blaze of light. They sometimes find themseves caught by fishermen in their nets. If held in the hand they contract, their bodies become hard and rigid, and the sea-water with which they are filled is ejected with force. We need not add that fishermen reject with disdain the Holothuria taken in their nets; the sea-cucumber has never been thought worthy of a place on our tables. "Truth is on this side, error on that," is a maxim as true in morals as in cookery. The sea-cucumber, which Europeans disdain, is a favourite dish among the Chinese. The fishery, preparation of, and transport of these animals to market, plays an important part in the commerce and industry of the East. One rather large species, the *Holothuria tubulosa*, in which, by-the-bye, a singular parasite fish (*Fierasfer Fontanesii*) lives, is common in the Mediterranean. This species is eatable, and much relished at

Naples. In the Ladrone Islands *Holothuria guamensis* is preferred. But nowhere is the Holothuria esteemed of such importance as in the Malayan and Chinese seas. In those countries, and on most of the shores of the Indian Ocean, the *Holothuria edulis*, vulgarly called *trepang*, is eaten with delight. Thousands of junks are annually equipped for the trepang fisheries. The Malay fishermen carry to this fishery a degree of patience and dexterity truly remarkable. Lying down in the fore part of their vessels, and holding in their hands a long bamboo terminating in a sharp hook, their eyes, accustomed to this fishing, frequently discover the animal at a distance of not less than thirty yards, as it creeps along the surface of the submarine rocks or corals. The fisher darts his harpoon at this distance, and seldom misses his prey. When the water is shallow, that is to say, not more than four or five fathoms deep, divers are sent down to obtain these culinary monsters, who seize them in their hands, and in this manner can take five or six at a time. To prepare the fish and preserve them for transport to the markets, the Malay and Chinese fishermen boil them in water, and flatten them with stones. They are then spread out on bamboo mats to dry; first in the sun, and then by smoking them. Thus prepared, they are enclosed in sacks, and shipped to the Chinese ports, where they are particularly esteemed. This fishery takes place in the months of April and May. (PLATE IX.)

In his voyage to the South Pole, Captain Dumont d'Urville, in traversing the Chinese seas, had an opportunity of assisting at this fishery, which he has described very graphically. We quote the passage in which the French navigator relates what he witnessed at this curious scene. "While the ships were lying quietly at anchor, we saw," he says, "entering the bay, four Malay proas, bearing Dutch colours, which dropped their anchors about a cable's length from Observatory Islet. The padrones or captains of these vessels soon presented their salutations, and informed me that they had started from Macassar at the end of October, with the western monsoon, and that they came to fish for Holothuria (trepang) along the coasts of New Holland, from Melville Island to the Gulf of Carpentaria, where the east wind met them, and assisted their return, when they revisited all the points of the coast, anchoring in every bay where they hoped to find fish. We were in the first days of April; the east monsoon was definitely established; the Malay fishermen were returning in their circuit, and in passing, they came to exercise their industry in Raffles Bay. An hour after their arrival they were all at work, and the shed for the preparation of their fish was established

IX— Fishing for and curing the Holothuria in the Indian Ocean

within our view. The roadstead had no longer the aspect of a vast solitude: wreaths of smoke crowned the summit of Observatory Island, where, as if by enchantment, several large sheds had sprung up, while numerous vessels, supplied with divers, were proceeding to fish for Holothuria, which were passed immediately to the furnaces erected for curing them. In the course of my voyage I had often remarked little walls constructed of dry stones, consisting of several half-circles joined one to the other. I had often, but vainly, tried to discover the use of these little structures: I was now enlightened. The Malays arrived. Their boats were scarcely anchored when several large boilers, in the shape of a half-sphere, the diameter of which might be about forty inches, were placed upon the stone walls of which I have spoken, and now served as improvised furnaces. Near to them are sheds composed of four strong posts driven into the ground, supporting roofing covered with hurdles, on which it is probably intended to dry the Holothuria. During their sojourn in this bay, the fishermen, having fine weather, made no use of these sheds, having probably only prepared them as a precaution.

"A crowd of men actively employed in building their sheds gave an unaccustomed appearance to the bay, which could not fail to attract the savage inhabitants of the mainland. Very soon, indeed, we could see them hastening from all sides, and nearly all reached the little island, either by swimming or wading through the sheet of shallow water which separates it from the mainland. I only saw one pirogue, made of the bark of a tree badly put together, which gave a passage to three of these visitors. When night arrived, the Malays had finished all their preparations; some of them remained to guard what they had left on shore, all the others returned to their boats.

"In the interval, a boat from the *Astrolabe* being wanted to carry some visitors from the island, I profited by the occasion to visit one of the proas, accompanied by M. Roquemauel. We were received with much politeness, and even cordiality, by the captain or padrone of the boats. He showed us over his little ship. The keel appeared to us sufficiently solid; even the lines did not want elegance; but great disorder seemed to reign in the stowage department. From a kind of bridge, formed by hurdles of bamboos and junk, we saw the cabin, which looked like a poultry-house; bags of rice, packets, and boxes were huddled together. Below was the store of water, of cured trepang, and the sailors' berths. Each boat was furnished with two rudders, one at each end, which lifted itself when the boat touched the bottom. The craft was furnished with two masts, without shrouds,

which could be lowered on to the bridge at will by means of a hinge; they carry the ordinary sail; the anchors are of wood, for iron is rarely used by the Malays; their cables are made of ratan fibre; the crew of each bark consists of about thirty-seven, each shore-boat having a crew of six men. At the moment of our visit they were all occupied in fishing operations, some of them being anchored very near to us. Seven or eight of their number, nearly naked, were diving for trepang; the padrone alone was unoccupied. An ardent sun darted its rays upon their heads without appearing to incommode them, an exposure which no European could hold up under. It was near mid-day, and the moment, as our Malay captain assured us, most favourable for the fishing. In fact, we saw that each diver returned to the surface with at least one animal, and sometimes two, in his hands. It appears that the higher the sun is above the horizon, the more easily is the creature distinguished at the bottom. The divers were so rapid in their movements, that they scarcely touched the boat, into which they threw the animals, before they dived again. When the boat was filled with them, it proceeded to the shore, and its place was supplied by an empty one. I followed one of these, to witness the process of curing which they adopted.

"The Holothuria of Raffles Bay is from five to six inches long, and about two in diameter; it is a gross fleshy mass, somewhat cylindrical in form, but no external organ is visible. The mollusc glues itself to the rocks at the bottom of the sea, and, as it can only move very slowly, the Malay divers seize it readily. The greatest merit of a fisherman is to have a practised eye, to distinguish the animal at the bottom, and to dive directly to the spot where it lies. To preserve them, the fishermen throw them, while still living, into a cauldron of boiling sea water, where they are stirred about by means of a long pole, which is supported upon another pole fixed in the earth, but having a forked end, which acts as a lever. In this process the trepang gives up all the water it contains, and is withdrawn at the end of two minutes. A man armed with a large knife now extracts the entrails, and it is thrown into a second cauldron, having only a small quantity of water, seasoned with mimosa bark. The object of this second operation is to smoke the animal, in order to preserve it the better, for the bark is consumed in the process. The trepang is now placed upon hurdles and dried in the sun. When sufficiently dried, it is stowed away in the hold of the proa.

"It was about two o'clock in the afternoon when the divers ceased their labours and came ashore. My tent was soon surrounded. I recognised the captain of the proa among those who had previously

visited me. He approached and examined all the instruments used in the observatory with great attention, seeking to discover their use. I showed him a gun with percussion cap, which astonished him greatly, especially when I pointed out to him its great superiority over the flint-lock. He assured me that these arms were still unknown in the Celebes, his country; but he failed to convince me of that. He questioned me as to the places we had visited, and where we were going. I endeavoured to sketch a map of New Holland, New Zealand, and New Guinea upon a leaf. He then took my pencil, and added to it the Indian Archipelago, the coasts of China and Japan, and the Philippine Islands. Surprised in my turn, I asked him if he had visited all these places. He replied in the negative, but added that he knew their position perfectly, and could easily take his vessel to any of them. Finally, the interview terminated by his asking for a glass of arrack. I do not know if this intelligent Malay professed the Mahometan religion, but I do know that he drank half a bottle of wine and a quarter of a pint of arrack without being at all the worse for it. He then offered me some prepared trepang, inviting me to taste it, which I did; to me it appeared to resemble the lobster in taste. My men liked it, and thankfully accepted the captain's offer; for my part, I felt an utter repugnance even to taste it.

"According to the account I had from the Malay captain, the price of trepang in the Chinese markets was fifteen rupees (about thirty shillings) the pekoul, or a hundred and twenty-five pounds. He estimated his cargo to be worth about a hundred and twenty pounds. The fishing had occupied him and his crew three months. From the earliest times this commerce has belonged exclusively to the Malay fishermen, and it will always be difficult for Europeans to compete with them. The Malay vessels are equipped on the most economical principle, and the men are wanting neither in sobriety, intelligence, or activity.

It was nearly four o'clock when the Malays finished their operations. In less than half an hour they had embarked their cargo; the tents were struck, and, together with the boilers, carried back to the boats, which were already preparing to set sail. At eight o'clock in the evening they hoisted sail and left the bay."

Some idea may be formed of the extent and importance of the Holothuria fishing by the number of ships which it attracts in this part of the East. Captain King assures us that 200 vessels annually leave Madagascar to fish for the *sea slug*, as it is sometimes called. Captain Flinders, being on the coast of Australia, learnt that a fleet

of sixty vessels, having a hundred men on board, had left Madagascar two months previously in the same pursuit.

Among the Holothuria, one particular genus, *Synapta*, is distinguished from others of the family by the absence of the ambulacral feet, and by the fact of its uniting both sexes in one individual. *Synapta Duvernæa* is represented in PLATE X. M. Quatrefages, who discovered it in the Channel, gives the following description of it in his work, "Les Souvenirs d'un Naturaliste." "Imagine," he says, "a cylinder of rose-coloured crystal, as much as eighteen inches long and more than an inch in diameter, traversed in all its length by five narrow ribbons of white silk, and its head surmounted by a living flower, whose twelve tentacles of purest white fall behind in a graceful curve. In the centre of these tissues, which rival in their delicacy the most refined products of the loom, imagine an intestine of the thinnest gauze gorged from one end to the other with coarse grains of granite, the rugged points and sharp edges of which are perfectly perceptible to the naked eye.

"But what most struck me at first in this animal was, that it seemed literally to have no other nourishment than the coarse sand by which it was surrounded. And then, when, armed with scalpel and microscope, I ascertained something of its organisation, what unheard-of marvels were revealed! In this body, the walls of which scarcely reach the sixteenth part of an inch in thickness, I could distinguish seven distinct layers of tissue, with a skin, muscles, and membranes. Upon the petaloid tentacles I could trace terminal suckers, which enabled the Synapta to crawl up the side of a most highly polished vase. In short, this creature, denuded to all appearance of every means of attack or defence, showed itself to be protected by a species of mosaic, formed of small calcareous shield-like defences, bristling with double hooks, the points of which, dentated like the arrows of the Caribbeans, had taken hold of my hands."

If one of these Synapta is preserved alive in sea-water for a short time, and subjected to a forced fast, a very strange phenomenon will be observed. The animal, being unable to feed itself, successively detaches various parts of its own body, which it amputates spontaneously. A great compression or ring is first formed, and then the separation of the condemned part takes place quite suddenly. "It would appear," says M. Quatrefages, "that the animal, feeling that it had not sufficient food to support its whole body, was able successively to abridge its dimensions, by suppressing the parts which it would be most difficult to support, just as we should dismiss the most useless mouths from a besieged city."

X. Suspecta Dumerae (Quatrefages)

This singular mode of meeting a famine is employed by the Synapta up to the last moment. After a few days, in fact, all that remains of the animal is a round ball, surmounted by its tentacles. In order to preserve life in the head, the animal has sacrificed all the other parts of its body.

In order to find natural novelties, to find unforeseen subjects of study and reflection, it is not necessary to run over the world or travel great distances. It is only necessary to visit the banks of the nearest river, or descend to the sea-shore, and let the sea reveal a fragment of the marvels which it conceals in its bosom.

MOLLUSCA.

THE class Mollusca—pulpy animals—forms a grand division which naturalists have been pleased to make in the animal kingdom, it comes immediately below the Vertebrata and above the Annulosa, which again stand above the Cœlenterata, which includes the polyps, sea-anemones, hydras, and corals, which last, as we have seen, are more highly organised than the Protozoa.

The Mollusca may be divided into two groups, the Mollusca proper and the Molluscoida. The Mollusca proper, as represented

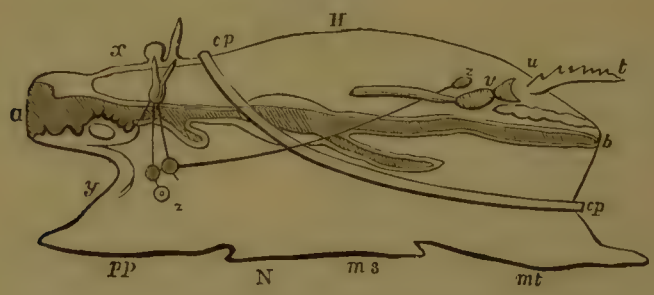


Fig. 119.—P. C. Mollusca.

in Fig. 119, present the following parts, and are supposed to be bilaterally symmetrical: H, is the hæmal parts, in which the heart is situated, commonly called the dorsal part, although the word is used in a different sense in different divisions of the animal kingdom. In the same manner the opposite region (N) is not termed the ventral, but the neural region, in philosophical anatomy. It is the region in which the great centres of the nervous system are placed. One termination (*a*) is the anterior or oral region; the other end (*b*), the posterior or anal region; between these extremities the intestines take a straight course. The neural surface is that upon which the majority of molluscs move, and by which they are supported, and it is commonly modified to subserve these purposes by the formation of a

muscular expansion or disc, called the foot. Three regions, in many genera very distinctly divided from one another, may be distinguished in this foot: an anterior, the *Propodium* (*p p*); a middle, the *Mesopodium* (*m s*); and a posterior, the *Metapodium* (*m t*). In addition to these, the upper part of the foot, or middle portion of the body, may be prolonged into a muscular enlargement on each side, just below the junction of the hæmal with the neural region, this forms the *Epipodium* (*e p*). The mass of the body between the foot proper and the part of the abdomen which bears the epipodium may be termed the mid-body, or *Mesosoma*. On the upper part of the sides of the head are two pairs of organs, namely, the eyes and the tentacles. In the hæmal region the integument may be modified and raised up into a fold at the edges, either in front or behind the anus. When so modified, it is called a mantle, *Pallium*. In front of the anus, again, the *branchiæ* (*t*) project as processes of the hæmal region. Among the internal organs, the heart (*u v*) lies in front of the branchiæ in the hæmal regions, the nervous ganglia (*x y z*), of which there are three principal pairs, being arranged around the alimentary canal, which they encircle.

Such is the general type of the class Mollusca, of which, however, the variations are innumerable. They are all soft-skinned animals, without either articulated exterior or annulose external skeleton. Their nervous system, being without cerebro-spinal axis, is entirely composed of ganglions, which are all reunited in the œsophagus, without constituting in any case a lengthened median chain. Their digestive system is complete—that is, it is provided with two apertures; their principal organs are symmetrical and according to a plan, usually curving, by which their bodies are divided into two parts.

The first series or subdivision, to which Milne-Edwards has given the name of *Molluscoïda*, includes under that term the Polyzoa and the Tunicata.

CHAPTER X.

MOLLUSCOÏDA.—POLYZOA.

THE Bryozoa, or Polyzoa—as British naturalists for good reasons prefer to call them—form the boundary-line which divides the humble mollusc from the humbler zoophytes. In consequence of this intermediate organisation, these creatures were long considered as polyps; but De Blainville, Milne-Edwards, Ehrenberg, and Vaughan Thompson, almost simultaneously began to separate them from the molluscs, and form them into a separate group. Subsequent naturalists, while considering the Molluscoïda as truly and wholly molluscous, admit that the distinction proposed by Milne-Edwards, is most important, and should be retained as a primary subdivision, confining it to those molluscs which have the neural region comparatively little developed, and the nervous system reduced to a single or at most a pair of ganglia, and the mouth surrounded by a more or less perfect circle of tentacles, an arrangement which would also place the *Brachiopoda* in the group *Molluscoïda.*

Marine plants are sometimes observed to be quite covered with velvety parasites, which might at a first glance be mistaken for a sea moss. This, however, is simply an aggregation of Polyzoa, each of which has its separate cell, which is placed quite contiguous to its neighbour.

These little creatures are thus entirely distinct. Each cell is formed by the integument, which has been encrusted by calcareous salts, or other organic matter, hardened after the manner of a horn. This kind of covering protects the animal from the attacks of its enemies. This mode of retreat at the bottom of a protecting shell is very frequently adopted in the whole series of molluscs. The oyster shuts itself up by closing its valves, and the snail retires into its shell. This assemblage of small cells presented by the Polyzoa has long been mistaken in some forms at least for Zoantharian corals.

Each animal has its own opening, and is furnished with a dentate, spinous enclosure, or protected by an operculum or lid; they present themselves under every variety of form, sometimes as an assemblage

of branching tubes, occasionally a rounded mass of spongy appearance, and now as a flat lamelliform inarticulated expansion of cells. With some of the marine species the shell of the mussel is covered as with a fine lace.

It is a remarkable fact that these cells are not always inert. They seem to enjoy some little power of motion. It is well known that the leaves and branches of the sensitive plant (*Mimosa*) contract and expand under the touch of the finger; the same phenomenon, according to Mr. Rymer Jones, takes place on touching the cells of certain species of Polyzoa. The moment they are touched they quickly incline themselves; and the movement is immediately communicated from one to the other, until all the cells of the community are in motion.

Returning to the organisation of the little creature which occupies the cell, it is found that the upper and retractile portion, which is of extreme delicacy, terminates anteriorly in a circle of long tentacles, in the centre of which is the mouth. These tentacles are fringed laterally by a series of vibratile cilia. "When the animal displays itself," says Frédol, "this circle of microscopic threads of extreme tenuity first show themselves rising from the summit of the cell; this is followed by the upper part of its body, which is more or less flexible; the tentacles follow between the threads, pushing them on one side."

These tentacles are furnished on the back with appendages like very fine hairs, attached to them nearly at right angles, in addition to the delicate cilia already spoken of, which play a very important part in the arrangements of most microscopic animals. At the moment when the tentacles appear outside the cell, the body of the animalcule, which has the power of expanding or contracting itself, is gradually unrolled. It soon spreads out its pretty little arms, the appendages and cilia beginning their rapid vibrations, until the eye, deceived by the rapidity and regularity of their movements, is dazzled, and the beholder begins to think that he sees rosy drops of dew waving to and fro, twisting and untwisting themselves. The corpuscles which float round the animal are violently agitated, as if they were under the influence of some strong breeze. Unhappy, indeed, is the fate of the unfortunate Infusorium which chance leads at this moment into the fatal circle.

Darwin, who examined some of these creatures very minutely, tells us that "several genera (Flustra, Eschara, Cellaria, Cresia, and others) agree in having singular movable organs attached to their cells. The organs in the greater number of cases very closely resemble

the head of a vulture; but the lower mandible can be opened much wider than a real bird's beak. The head itself possesses considerable powers of movement, by means of a short neck. In one polyzoon the head itself was fixed, but the lower jaw free; in another it was replaced by a triangular hood, with a beautifully-fitted trap-door, which evidently answered to the lower mandible. In the greater number of species each cell was provided with one head, but in others each cell had two.

"The young cells at the end of the branches of these polyzoa contain quite immature forms, yet the vulture heads attached to them, though small, are in every respect perfect. When the animal was removed by a needle from any of the cells, these organs did not appear to be in the least affected. When one of the vulture-like heads was cut off from a cell, the lower mandible retained its power of opening and closing. Perhaps the most singular part of their structure is, that when there are more than two rows of cells on a branch, the central cells were furnished with these appendages of only one-fourth the size of the outside ones. Their movements varied according to the species; but in some I never saw the least motion, while others, with the lower mandible generally wide open, oscillated backwards and forwards at the rate of about five seconds each turn; others moved rapidly and by starts. When touched with a needle, the beak generally seized the point so firmly that the whole branch might be shaken."

Moreover, in *Cresia*, Darwin observed that each cell was furnished with a long-toothed bristle, which had the power of moving very quickly; each bristle and each vulture-like head moving quite independently of each other; sometimes all on one side, sometimes those on one branch only moving simultaneously, sometimes one after the other. In these actions we apparently behold as perfect a transmission of will in the polyzoon, though composed of thousands of distinct animals, as in any individual animal. "What can be more remarkable," he adds, "than to see a plant-like body producing an egg, capable of swimming about and choosing a proper place to adhere to, where it sprouts out into branches, each crowded with innumerable distinct animals, often of complicated organisation—the branches, moreover, sometimes possessing organs capable of movement independent of the animals!"

The prey which is drawn into the vortex by the tentacles and their cilia enters into the mouth, to which is attached a pharynx, œsophagus, stomach, and intestines. In the hæmal region, not far from the mouth, there is a special opening for the intestine.

Respiration is provided for in the Polyzoa by the ciliated appendages which surround the mouth; they are at once tentacula and branchiæ. The animal presents no other trace of organs of the special senses. A small ganglion and a few threads constitute all of the nervous system which can be traced; neither heart nor blood-vessels have been found.

The egg, in the case of the Polyzoa, gives birth to a young animal covered with cilia on its surface; it swims about freely until it has chosen a convenient place in which it can establish the new colony which it is to originate. At first, the number of the colony is only increased by budding, but in a short time the individual polyps produce eggs.

From these remarks it will be seen that the animals of the Polyzoa are more complex in their form and functions than those of the Cœlenterata, and the further study of their anatomy confirms this conclusion. In their case the digestive organs are no longer a simple sac with a single orifice; there is a mouth, a pharynx, a gullet, a gizzard, a membranous stomach and intestines, with a special opening for these latter. We have descriptions of some species in which the gizzard seems to be provided with a certain number of interior teeth, forming a wonderful pavement—a living mill for the purpose of grinding the food before it enters into the second stomach. The organisation of this small creature reveals to our eyes a wonderful amount of combination—of admirable art immeasurably surpassing all that the most perfect human industry and human genius could accomplish.

After this general view of the organisation of the group, we shall proceed to introduce the reader to some of the more characteristic species.

Under the leaves of water-lilies (*Nymphea*), pond-weed (*Potamogeton*), or upon floating fragments of submerged wood, are generally to be found certain *Polyzoa*, animals described by Trembley under the name of *plumed polyps*. These will probably belong to the genus *Plumatella* (Fig. 120). These little diaphanous creatures constitute colonies which under the microscope resemble small branching shrubs; they consist of small slender tubes fastened one to the other, and having from forty to sixty retractile tentacula, which expand like the petals of a flower; they are furnished with vibratile cilia, the movements of which serve the purpose of leading food into the mouth.

Another genus, which is found in ponds in France, and which is also found in fresh water in Britain, is the *Cristatella* of Cuvier. "Perfect specimens of *C. mucedo* occur from six lines to twenty-four

in length by two or three in breadth," says Sir J. G. Dalyel, "of a flattened figure, fine translucent green colour, and fleshy consistence. Some of the shorter tend to an elliptical form, but those of larger dimensions are linear, with parallel sides and curved extremities. The middle of the upper and the whole of the under surface are smooth, the former somewhat convex, occasioned by a border of seventy or eighty, even up to 350 individual polypi, dispersed

Fig. 120.—Plumatella cristallina, magnified (after Allman).

Fig. 121.—Cristatella mucedo (Cuvier) (after Allman).

in a triple row, their number depending entirely on the size of the specimen. Each of these numerous polypi, though an integral portion of the common mass, is a distinct animal, endowed with separate action and sensation. The body rising about a line above a tubular fleshy stem, is crowned by a head, which may be circumscribed by a structure of a horse-shoe shape, and bordered by a hundred tentacula. Towards one side, the mouth, of singular mechanism, seems to have projecting lips, and to open as a valve, which folds up within, conveying the particles which are absorbed to the wide orifice of the intestinal organ, which descends, forming a

convolution below; and returns again, terminating in an excretory orifice under the base of the tentacula."

The inhabitants of the colony are thus united in great numbers under one common envelope; a peculiar downy appearance is produced by the collection of tentacula belonging to this curious colony. The filamentous looking mass is the translucent row of cells in which

Fig. 122.—Flustra foliacea (Linnæus).

the polyps are lodged, and to which they retreat when disturbed. These cells are sometimes free in part, sometimes completely rooted to the stems of aquatic plants. The tentacles are of a fine transparent glass colour, the body being of a brown colour. Fig. 121 represents *Cristatella mucedo*, which is not uncommon both in this country and in France.

Most naturalists have now agreed to place among the Polyzoa

all the species of *Flustra*, of *Eschara*, and other now well-known genera.

All the species of the genus Flustra are marine, whose integument in hardening forms a thin shell of a horny appearance; their little cells, more or less horny, are often grouped symmetrically, somewhat like the cells in a bee-hive. Sometimes they form a crust which covers algæ and other marine bodies; sometimes they form ribbon-like stems. In some species the cells are only found on one side; in others they occupy both. Their orifices are extremely small, and are often defended by spines quite microscopic (*F. foliacea*, Fig. 122).

Their tentacles, like other Polyzoa, are covered with cilia, always vibratile, disposed in a straight line, which in their movements produce the effect which a row of animated pearls might be supposed to produce if rolled upwards from the base to the summit of the organ.

Some species of the genus Eschara form quite shrub-like masses, calcareous in structure, the polyp cell being imbedded in the mass. Some of them may be very easily, by superficial observers, mistaken for species of the Zoantharian genus *Millepora*, but the structure of the animal is quite enough to distinguish them. *E. cervicornis* is common around the coasts of Great Britain and Ireland. As it is with the corals, so it is here; each eats for the benefit of itself and for the community—labour and nutrition for the community, labour and food for itself.

Molluscoïda—Tunicata.

On seeing one of the *Tunicata* for the first time, a stranger to zoology would scarcely take them for animals at all. Almost always attached to submarine rocks, these beings have the form of a simple sac. Their skin, gelatinous, or horny, is at times covered over with marine plants and polyps. They have neither arms, nor feet, nor head; but then they have a mouth, placed at the entrance of a digestive tube, and, in connection with the latter, a special opening intended for the excreta. The mouth is at the bottom of a great cavity, the walls of which are covered with blood-vessels; for this cavity is the seat of respiration, and is covered with vibratile cilia. Thus the same canal serves first for respiration, and then, as an entrance to the cavity for digestion, another instance of the economy of Nature. Another remarkable fact in connection with their circulation is found: their heart is the centre of a well-developed vascular system, but unlike what is usually found in animals, the blood which traverses it takes such a course that, in the space of a few minutes, the auricle and ventricle of the heart become changed into ventricle and auricle

respectively, at the same time the arteries are changed into veins and the veins into arteries, and this in consequence of the current which traverses these canals changing its direction after certain contractions of the heart.

Simple as is their organisation, the Tunicata have a nervous system. It is a single ganglion, connected with divers small threads. The organs of sensation present themselves in a very rudimentary fashion,

Fig. 123.—Ascidia microcosmus (Cuvier).

for after very minute search, eyes have been found. The Tunicates are propagated by budding, and also from eggs. The young are subject to some very curious metamorphoses, some particulars of which will be given farther on.

Some species of the Tunicates are free, some are united to others in a manner more or less intimate. Hence their division into the three groups of *simple*, *social*, and *compound* Tunicates.

The genus *Ascidia* is one of the best known among the simple Tunicates. The term is derived from the Greek word ἀσκιδίον, leather bottle, and it has, as indicated by the name, the shape of a bottle or purse. The analogy becomes more evident when it is considered that these creatures are habitually filled with water, which can be expelled by very slight pressure.

Simple Tunicates attach themselves, each individual singly, to

rocks and other marine bodies, and generally at a fixed depth. *Ascidia microcosmus*, a Mediterranean species, represented in Fig. 123, may be given as an example of this division of Tunicates. The name of microcosmus, or the little world, is probably given to the species from its being inhabited by quite an animated colony of algæ and corals, which dwell upon its surface, and give it a very peculiar, but not very attractive, appearance. The flavour of these molluscoids is very strong, which does not, however, hinder the poorer dwellers on the sea-shore from eating them. *Phallusia* is another genus of the group. *Phallusia grossularia* is of a reddish colour, and about the size of a currant-berry: it usually lodges itself in the oysters of certain localities. At Ostend another species, *Phallusia ampulloïdes*, is found in prodigious quantities in the oyster parks, and is parasitic on living lobsters.

Fig. 124.—Ascidia pedunculata (Milne-Edwards).

Social Tunicates embrace such forms as are connected together by a common stoloniferous prolongation, but remain free and unconnected in all other respects. *Ascidia pedunculata* (Fig. 124) may be given as an example.

The Composite Tunicates are still more intimately associated together; a great number of these little beings living together in a single mass. Such are the many species of such genera as Botryllus and Pyrosoma.

Botryllus is a genus perhaps the most interesting of all those under

consideration. Only imagine from ten to twenty individuals, oval in form, more or less flattened, adhering by their dorsal surface to some submarine body, and connected together by their sides, so as to be shaped into the form of a star. "When we excite one of the rays," says Frédol, "a single mollusc contracts itself; when we touch the centre, they all seem to contract themselves (Cuvier). The buccal orifices are at the circumference of the star, but the intestinal terminations abut upon a common cavity, which occupies the centre of the star. Here we behold certain animals which eat separately, but which fulfil together as a community very singular functions—a kind of union and communism of which the moral world presents no prototype. With our molluscs we have a score of individuals united. We may consider the entire star as one single animal with many mouths. But, then, we have with it a luxury of organs for the function of intelligence which seeks and chooses, and parsimony of the organ of stupidity, which neither seeks nor chooses."

While the species of the genus Botryllus are fixed and adherent, those of the genus Pyrosoma, on the contrary, are oceanic. The animal colony which constitutes it floats and balances itself upon the waters, being capable of fully contracting and dilating itself.

The name Pyrosoma has been given to these animals in consequence of their brilliant phosphorescent properties. According to the observations of Péron and Lesueur, nothing can exceed the brilliant and dazzling light emitted in the bosom of the ocean by these animals. From the manner in which the colonists dispose themselves, they form occasionally long trains of fire; but it is a singular fact that this phosphorescence presents the same curious characteristics that are seen in the play of colours caused by the rapid movements of the cilia of the Beroë; namely, that the colours vary instantaneously, passing with wonderful rapidity from the most intense red to yellow, from golden colour to orange, to green, or to azure blue. Von Humboldt saw a flock of these brilliant living colonies floating by the side of his ship, and projecting circles of light having a radius of not less than twenty inches in diameter. He could see by this light the fishes which followed the ship's track, during many nights, at the depth of from two to three fathoms.

Bibra, a Brazilian navigator, having caught six Pyrosoma, employed them to light up his cabin. The light produced by these little creatures was so bright, that he could read to one of his friends the description he had written of these his living torches.

Several species of Pyrosoma are known; *P. elegans*, about two or three inches in length, inhabits the Mediterranean; *P. giganteum*

is also found in the same sea. It is a long bluish cylinder shape bristling with bracts, at the base of each of which is the abode of a polyp, a citizen of this moving republic, which is attached to its colleagues by means of its gelatinous envelope, an alliance imposed by inexorable Nature.

Another species, *P. atlanticum*, was discovered by Péron and Lesueur in the equatorial seas.

These curious Tunicates grow in such a manner as to constitute a long fine cylindrical tube, closed at one end and open at the other. By the contraction and dilatation of the mass of beings, this great cylinder swims slowly through the open sea, lighting up the ocean with its phosphorescent light, shining through the water like a glowing fire. Mr. Bennett thus describes the phenomenon presented by these creatures. "On the 8th of June, being then in lat. 30° S. and 27° 5′ W. long., having fine weather and a fresh south-easterly trade-wind, and the thermometer ranging from 78° to 84°, late at night the mate of the watch called me to witness a very unusual appearance in the water. This was a broad and extensive sheet of phosphorescence extending from east to west as far as the eye could reach. I immediately cast the towing net over the stern of the ship, which soon cleaved through the brilliant mass, the disturbance causing strong flashes of light to be emitted, and the shoal, judging from the time the vessel took in passing through the mass, may have been a mile in breadth. On taking in the towing-net, it was found half filled with *Pyrosoma atlanticum*, which shone with a beautiful pale greenish light. After the mass had been passed through by the ship, the light was still seen astern, until it had became invisible in the distance, and the ocean became hidden in the darkness as before this took place.

"The second occasion of my meeting these creatures was in a high latitude, and during the winter season. It was on the 19th of August, the weather dark and gloomy, with light breezes from north-north-east, in lat. 40° 30′ S., and 138° 3′ E. long., at the western entrance to Bass's Straits, and about eight o'clock P.M., when the ship's wake was perceived to be luminous, while scintillations of the same light were abundant all round. To ascertain the cause, I threw the towing-net overboard, and in twenty minutes succeeded in capturing several Pyrosoma, which gave out their usual pale green light; and it was, no doubt, detached groups of these animals which were the occasion of the light in question. The beautiful light given out by these molluscans soon ceased to be seen; but by moving them about it could be reproduced for some length of time after. The luminosity

of the water gradually decreased during the night, and towards morning was no longer seen."

Salpa (Fig. 125) forms another most interesting genus of Tunicata; it contains forms presenting the appearance of long transparent masses of the most delicate tissue, composed of rows of individuals placed side by side, and grafted, as it were, transversely—ribbons, in which each animal is grafted end on end to its sister—double parallel chains of social creatures, sometimes alternate, sometimes opposite; living chaplets, of which each pearl is an individual. Each individual presents an oblong diaphanous or prismatic body, more or less symmetrical, and often furnished in front, rarely behind, with tentaculiform appendages. So great is their transparency, that

Fig. 125.—Salpa maxima, magnified (Forsk.).

the various organs may be observed through the skin as they perform their several functions.

Momus, an ancient philosopher, thought it a subject of regret that Nature had not thought of piercing the body with an opening sufficiently large for each one to see what was passing in the interior. The creature which now occupies our attention would surely have satisfied the demands of the philosopher—its body is, metaphorically speaking, a house of glass.

In order to move itself about the Salpa introduces water into its body through a posterior opening, furnished with a valve, which it expels by an anterior outlet situated near the mouth. It is thus pushed backwards, and swims, as it were, by recoil. Moreover, it swims with its ventral surface upwards. All the zooid forms of a chain of Salpa act in concert; they contract and dilate simultaneously; they advance as a single individual. They often float on the surface

of the sea with the undulations of a serpent, so that among sailors they have gained the appellation of sea-serpents. These long living trains abound in the Mediterranean, principally towards the African coast and in the equatorial seas, and they are often met with on the south-western shores of Ireland. They are inhabitants of the open sea, and live immersed at considerable depths; but when the nights are calm they show themselves on the surface. As they spread

126.—Phosphorescent chain of Salpas on the surface of the sea.

themselves abroad, and set aglow their strong phosphorescent light they resemble long ribbons of fire, unrolling their long waving lines in spite of the waves, as in Fig. 126. What wonders they see who go down into the great deep! What sights are reserved for the navigator who traverses the semi-tropical seas during the silence of night!

When a chain of Salpa is drawn from the water, the zooid forms separate, and they can no longer be made to adhere. The social bond has been dissolved.

Salpæ are sometimes met with, isolated and solitary, whose exterior conformation differs much from that which is proper to the

connected Salpa; so different, indeed, that it might well appear to belong to another type. Chamisso, Krohn, and Milne-Edwards have ascertained that the Salpa undergoes what is called an alternation of generation, the young creature being unlike its immediate parent. One of these generations is represented by the solitary individuals, the other by the aggregation of individuals. Each solitary Salpa engenders a new form, which is the chained form; whereas each constituted member of the chain engenders a solitary Salpa.

Thus a Salpa is not organised like its mother or daughter, but rather like its sister, its grandmother, or granddaughter—another example of alternate generation, which has already been discussed in treating of some of the Hydrozoa.

These marine creatures, which pass their lives in a forced community—animals which eat, sleep, or rest always in company—who abandon themselves together to the soft caresses of the waves—these colonies, or rather republics of animals, leading constantly the same monotonous existence—reveal to us very strange things: an identical community of sentiments in a crowd of beings riveted by the same chain, a chain at once physical and intellectual.

CHAPTER XI.

ACEPHALOUS MOLLUSCA.

"Sigillatim mortales, cunctum perpetui."—APULEIUS.

THE Mollusca proper were divided by Cuvier into five great sub-classes:—1. Lamellibranchiata, or Acephalous Mollusca, often called Conchifera. 2. Brachiopoda. 3. Gasteropoda. 4. Pteropoda 5. Cephalopoda.

The name Mollusca indicates the characters of this class which most struck the ancients: they are soft—in Latin, *mollis:* their flesh is cold, humid, and viscous. In consequence of their very softness, they are generally furnished with an apparatus of defence, or protection, in the shape of a calcareous covering, called a *shell.* According to the species this test may represent a coat of mail, a buckler, or a tower. The mollusc is thus armed and defended against all attacks from without, nearly after the manner of a knight of the middle ages; only the knight was not quite shut up in his armour, while the mollusc is attached to it by indissoluble organic bonds. "Such a life and such a habitation!" says Michelet. "In no other creature is there the same identity between the inhabitant and the nest. Drawn from its own substance, the edifice is the continuation of its fleshy mantle. It follows its form and tints. The architect has communicated its own substance to the edifice."

The shell of the Mollusca has been variously accounted for by naturalists. "We might regard the shell as the bone of the animal which occupies it," says a celebrated French naturalist; and then he gives expression to a very different view. "We may say as a general thesis that testaceous molluscs are animals with whom ossification is thrown out on the external surface in place of the interior, as in the mammals, birds, reptiles, and fishes. In the case of the superior animals the bones lie in the depths of the body; in the shelled Mollusca the bones are placed on the superficies. It is the same system reversed."

Other zoologists reject as altogether untenable both these com-

parisons. "The shell which serves as a dwelling and a shelter cannot," say these authors, "be considered as a skeleton, because it does not assume the external form of the animal; because it does not attach itself to the organs of locomotion; and, finally, because it is the product of secretion, which increases in proportion to the development of the body itself." The last two reasons appear to us to be the most acceptable.

However that may be, from the immense variety of form and size, from the beauty and brilliancy of their colours, the shells of the molluscs are among the most attractive objects of natural history. Nor is it from their beauty alone that a fine collection of shells becomes interesting: a living creature has inhabited the shell, a creature which in its organisation and its life, above all, by its habits, excites in a high degree our interest, curiosity, and admiration. It has been said that the shell "is like a medal struck by the hand of Nature to commemorate climates." In short, the waters of different regions of the globe, whether fresh or salt, are characterised by the presence of particular shells; moreover, the comparison of living shells with those which lie in a fossilised state buried in the depths of the soil is a most important element of our knowledge touching the origin of the different beds out of which our globe is constituted.

Thus, we must not shut our eyes to these beings, in appearance so miserable and obscure, if we would possess a general knowledge of the animal kingdom. The Creator has endowed them with many wonderful gifts to embellish their lives, and who would dare to disregard them? Who could examine and compare their structure without being charmed with the study? Man, who descends into the depths of the earth in search of the precious metals—who dives into the deep in pursuit of the treasures it conceals—who stoops his head over works of art—would surely not refuse to bend himself for a moment to the sand of the sea, to gather in his hand, to bring nearer to his eyes these marvellous works of the Divine Creator to be found thereon!

ACEPHALA.

We have seen that the Mollusca proper have been divided by Cuvier into five sub-classes—the first of these is called Acephala.

The Acephalous or Headless Molluscs are so called from the Greek ἀ, privative, and κεφαλή, head. They have no head; the body is surrounded by the folds of the mantle; the shell consists of two valves. Such is a summary description of all the Acephalous Molluscs. They are sometimes partially naked, but are for the most

part enclosed in a shell, whence they are known as Testaceous Molluscs. They are called *bivalves*, because their shell consists of two halves, or valves united by a hinge. They are sheltered in this double shell as a book is in its cover.

Although they have no head, they can feed themselves, and they reproduce their kind. They have friendships and enmities, perhaps even passions—probably these are not very lively, for most of them scarcely ever change their place, or even make the least movement; many of them remain fixed to the rock on which they were hatched, and tumultuous sensations are not quite compatible with immobility.

The bivalves* are found in every sea. The shells of the bivalve are ovoid, globulous, trigonal, heart-shaped, elongated like a pea-pod, or flat like the leaves of a tree. In some one valve is flat, the other round and swelling in the centre. The shell is thus an outer envelope, consisting of two pieces, more or less corresponding to each other in size and shape (of which the oyster is an example), formed of carbonate of lime deposited in membranous cells in its outer layers, the inner layers being composed of thin coatings of lime deposited in the outer surface of the mantle. The valves are united to the animal by the insertion into them of certain muscles, and the mantle-lobes stretch over to the edges of the valves. The ligament which unites the two valves consists of a dense elastic substance, somewhat resembling india-rubber; the hinge is formed of teeth in one valve and cavities in the other into which these teeth fit. The ligament acts in opposition to certain contractile muscles within, which draw the valves together, and is placed either within or without the hinge, or partly both. On separating the valves, the two folds of the mantle present themselves as thin delicate lamellæ or leaves furnished at the margin with sensitive tentacles and other organs of sense, and with glands sometimes highly coloured. The use of these organs is thus described by Mr. Rymer Jones:—

"When the animal is engaged in increasing the dimensions of its abode, the margin of the mantle is protruded and firmly adherent all round to the circumference of the valve with which it corresponds. Thus circumstanced, it secretes calcareous matter and deposits it upon the extreme edge of the shell, when the secretion hardens and becomes converted into a layer of solid testaceous substance. At intervals this process is repeated, and every newly-formed layer

* The term bivalve, as constituting a class, must be taken in a limited sense, for several genera, as Pholas for example, have also accessory valves.

enlarges the diameter of the valve. The concentric strata thus deposited remain distinguishable externally, and thus the lines of growth marking the progressive increase of size may easily be traced."

"While the margin of the mantle is thus the sole agent in enlarging the circumference of the shell," the author continues farther on, "its growth in thickness is accomplished by a secretion of a kind of calcareous varnish derived from the external surface of the mantle generally, which, being deposited layer by layer over the whole interior of the previously existing shell, progressively adds to its weight and solidity. There is, however, a remarkable difference in character between the material secreted by the marginal fringe and that furnished by the general surface of the mantle membrane. The former we have found more or less covered by glands appointed for the purpose, situated in the circumference of the mantle; but as these glands do not exist elsewhere, no colouring matter is ever mixed with the layers that increase the thickness of the shell, so that the latter always remain of a delicate whitish hue, and form the well-known iridescent material usually distinguished by the name of nacre or mother-of-pearl."*

The process by which shells attain their beautiful markings is thus described by Mr. Rymer Jones:—"The external surface is exclusively deposited by the margin of the mantle, which contains in its substance certain coloured spots, which are found to be of a glandular character, and to owe their peculiar character to a pigment they secrete, which is mixed with the calcareous matter; coloured lines are therefore found on the exterior of the shell wherever these glandular organs exist. Where the deposition of colour is kept up throughout the process of enlargement, the lines are unbroken and perfect; but where the coloured matter is furnished only at intervals, spots and patches of irregular form and increasing in size with the enlargement of the mantle are the consequence."

Many bivalves move about and change from place to place by means of an extensible fleshy organ called, from some of its functions, a foot; but in fact, it has less resemblance to a foot than to a large tongue. It is a muscular mass, capable of being pushed out from between the mantle lobes and the valves, and varies much in form; it resembles in turn a hatchet, a ventilator, a pole, an awl, a finger, and a sort of whip. This foot is simple, forked, or fringed. In some species the tissues of the foot are spongy, and capable of receiving considerable quantities of water. When the organ swells,

* "General Outline of the Animal Kingdom," p. 385.

it is elongated and stiff; on the other hand, by suddenly expelling all the water, it gets small and pliable, and can now return to its shell. This organ is represented in Fig. 127 (*Donax trunculus*, Linn.), in which it is singularly well developed. This bivalve is found on the sea-shore in shallow water; it buries itself almost perpendicularly in the sands. They are so abundant on the French side of the Channel and on the shores of the Mediterranean, that they form a considerable portion of the people's food. These bivalves have the singular power of leaping to a considerable height and then throwing themselves to a distance of ten or twelve inches—a spectacle which may be witnessed any day at low water. When abandoned by the retreating tide, they try to regain the sea. If seized by the hand, in order to drag them out of the sand, aided by their compressed, branched, and angular feet, they give to their shell

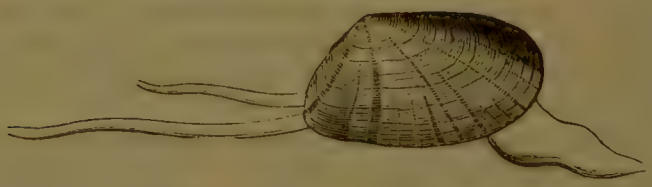


Fig. 127.—Donax trunculus (Linnæus).

the sudden and energetic movement under which the bounding action takes place. The shell of the genus Donax is slightly triangular and compressed; its length exceeds its height; it is regular, univalve, unequally lateral, and its hinge bears three or four teeth on each valve. The action of these feet is very simple, and is compared by Réaumur to that of a man placed on his belly, who, stretching out one hand, seizes upon some fixed object, and draws himself towards it. There is just this difference, that the movement of the member in the mollusc is altogether contractile.

Authors have described more than 4,000 species of bivalve molluscs, so that our space only permits us to describe a few families, or rather types of families.

The arrangement of bivalves now most generally adopted in England is that of the late Mr. Woodward, as developed in the last edition of his manual of the mollusca; it is greatly based on that of Lamarck. We have adopted his arrangement altered from a descending to an ascending scale of organisation.

The Lamellebranchiata, so called from the leaf-like form assumed

by the branchiæ, is divisible into two sections, the Siphonida, from the animals having respiratory siphons, and the Asiphonida, which are destitute of them.

The genus Mya may be taken as a type of the first, and the oyster of the second. The division Siphonida is divided into two sub-sections, those without and those with a pallial line sinuated. The first family of this latter section is the Pholadidæ, which includes the genera Teredo, Xylopagha, and Pholas, animals which possess extraordinary powers of boring, not merely through sand, but through the hardest rocks.

The genus *Teredo* consists of marine animals having a special and irresistible inclination for submerged wood; for while wood exposed to the air becomes a prey to terrestrial animals, so submerged wood is subject to invasion by aquatic animals, of which the Teredo is by far the most formidable. The Teredo in the bosom of the ocean perforates the hardest timbers, whatever be their hardness. The galleries bored by these imperceptible miners riddle the whole interior of a piece of wood, destroying it entirely, without the slightest external indication of its ravages. The galleries sometimes follow the grain of the wood, sometimes they cut it at right angles; the miners, in fact, change their route the moment they meet in their way either the furrows hollowed out by one of their congeners, or some ancient and abandoned gallery. By a strange kind of instinct, however multiplied may be their furrows or tubes in the same piece of wood, they never mingle—there is never any communication between them. The wood is thus attacked at a thousand diverse points, until it is invaded, and its entire substance destroyed. It is by secret ravages of this kind that the piles and other submarine constructions upon which bridges are built are often riddled and perforated. They appear to all outward examination as solid and perfect as at the moment they were first driven; but they yield to the least effort, bringing ruin and destruction on the edifices they support. Ships have been thus silently and secretly mined, until the planks crumbled into dust under the feet of the sailors. Others have gone down with their crews, their destruction being entirely caused by the ravages of these relentless enemies, which are terrible from their unapproachable littleness.

M. Quatrefages, who has minutely studied the organisation and habits of the Teredos in the Port of St. Sebastian, reports the following fact, which will give the reader some idea of the rapidity with which these dangerous molluscs pursue their ravages:—

"A boat, which served as a passage-boat between two villages on the coast, went down in consequence of an accident at the commence-

ment of spring. Four months after some fishermen, hoping to turn her materials to advantage, raised the boat. But in that short space of time the Teredos had committed such ravages that the planks and timbers were riddled and worm-eaten so as to be totally useless."

At the beginning of the eighteenth century, half the coast of Holland was threatened with annihilation because the piles which support its dikes and sea-walls were attacked by a species of Teredo; and it proved no contemptible foe. Many hundreds of thousands of pounds were expended in order to avert the threatened danger. Fortunately, a closer attention to the habits of the molluscs has brought a remedy to a most formidable evil; the mollusc has an inveterate antipathy to iron rust, and timber impregnated by the oxide of iron is safe from its ravages. The taste of the Teredo being known, it is only necessary, in order to avoid this dangerous mollusc, to sink the timber which is to be submerged in a tank of prepared oxide of iron—clothed, in short, in a thick cuirass of that antipathy of the Teredo, iron rust. Ships' timbers are also covered with the same protecting coating; but the copper in which ships' bottoms are usually sheathed serves the same purpose.

Fig. 128. Teredo navalis (Linnæus).

The singular Acephalous Mollusc, known to naturalists as the *Teredo navalis*, and popularly as the Ship Worm, has the appearance of a long worm without articulations. Between the valves of a little shell, with which it is provided anteriorly, may be seen a sort of smooth rim, which surrounds a swelling projecting pad or cushion. This cushion is the only part of the body of the animal which can be regarded as a foot. Starting from this point, all the body of the Teredo is enveloped by the shell and mantle, the latter of which forms a sort of sheath communicating by two siphons with the exterior (Fig. 128).

The mantle adheres to the circumference of the shell. The tissue of the mantle is of a greyish tint, very light, and transparent enough, especially in the young, to permit of the mass of the liver, the ovary, the branchiæ, and the heart being distinguished in the interior, even to counting the pulsations of the latter. The siphons are extensile, and attached the one to the other for about two-thirds of their length. It is by these tubes that the aërated water enters which feeds the

animal and enables it to breathe. It is discharged by the second tube, when deprived of its oxygen and no longer respirable, carrying with it also the useless products of digestion. This movement is continuous; but from time to time the animal shuts at once the orifices of both tubes, and slightly contracts itself.

The shell, seen on the side, presents an irregularly triangular form; it is nearly as broad as it is long; its two valves are solidly attached the one to the other above and below by the mantle, in such a manner as only to permit of very slight movements. It is coloured in yellow and brown lines; sometimes it is quite plain. On the upper edge of the anterior portion of the body of the animal is the mouth, a sort of funnel, flat and slightly bell-shaped, furnished with four labial palpi, a stomach without any peculiar feature, and a well-developed intestine.

The heart consists of two auricles and a ventricle, which beat at very irregular intervals, four or five in the minute. The blood is colourless, transparent, and charged with small irregular corpuscles. The act of breathing is accomplished in the branchiæ, or gills. Nevertheless, the one half of the blood returns to the heart without passing through these branchiæ.

The nervous system is well developed, and consists of nervous filaments, and of ganglions, which are distributed to the mantle, the branchiæ, the foot, and the siphon tubes.

The adult animal is surrounded by a sort of sheath, consisting of a solid shelly coat, which has sometimes been described, erroneously, as forming part of the animal. The Teredo, shut up in this tube, is limited in its movements; when observed in a vase, its motions are slow and deliberate—movements of extension and contraction, by the aid of which it contrives with difficulty to exchange its place; but nothing indicates a true creeping movement. In a state of nature, according to M. Quatrefages, the body of the animal is stretched out to three times its length without diminishing in any respect its proportional thickness; the afflux of water penetrating under the mantle, and of the blood which accumulates in the interior vessels, sufficiently accounting for a phenomenon which at the first glance is very singular.

The Teredo lays a spherical greenish-yellow egg. Shortly after fecundation, these eggs are hatched. At first naked and motionless, these larvæ are soon covered with vibratile cilia, when they begin to move, at first by a revolving pirouette, afterwards swimming about freely in the water. When one of these larvæ has found a piece of submerged wood, without which it probably could not live, the

curious spectacle is observed of a being which fabricates, step by step and as it requires them, the organs necessary for the performance of its functions. It begins by creeping along the surface of the wood by means of the very long tubes with which it is furnished. Then it is observed from time to time to open and shut the valves of the little embryo shell which partly envelopes it. As soon as it has found a part of the wood sufficiently soft and porous for its purpose, it pauses, attacks the ligneous substance, and soon produces a little depression or opening, which will be the entrance to the future tunnel.

Once fairly lodged in this little opening, the young Teredo is rapidly developed; it covers itself with a coating of mucous matter, which, condensing by degrees, assumes a brownish tint, forming a solid covering, with two small holes for the passage of the siphon tubes. At the end of three days this covering has become quite solid; it is the commencement of the calcareous tube, in which the animal is to attain its full size. When secured beneath this opaque screen, the little miner is no longer exposed to observation; but if his cell is opened at the end of a few days, it is found that it has secreted a shell, larger and more solid than the original one; and this is the shell of the adult animal.

The young Teredo, which feeds on the raspings of the wood, increases rapidly; it passes first from a spheroid form to an elongated shape, and when its body can no longer be contained in the shell, it projects beyond the edge, and would find itself naked were it not protected by its membranous sheath, which adheres to the walls of the ligneous channel, now the dwelling-place of the animal.

The process by which a creature soft and naked like the Teredo should break into a solid piece of the hardest wood so quickly, and destroy it with so much facility, was long a mystery. Until very recently, the shell was looked on as the implement of perforation. But in that case the shell should preserve certain traces of its action upon surfaces so resistant as oak and fir; but the shell, on the contrary, is in such cases perfect, with no signs of friction. On the other hand, the muscular apparatus of the Teredo is not well calculated to put the shell into rotatory action, were the process a boring one. It does not seem therefore possible to attribute these perforations to a simple physical action.

Some naturalists have suggested, in explanation of this phenomenon, that the animal is furnished with the means of secreting a liquid capable of dissolving the woody fibre. This has been met by the statement that, in whatever way the wood is attacked, whether the gallery is excavated with or across the fibre of the wood, the groove

s as exactly and neatly cut as if it had been perforated by the harpest tool, and that a corroding dissolvent could not act with this egularity, but would attack the harder and more tender parts unequally. This objection, which M. Quatrefages opposes to the idea of a chemical solvent, appears to us to admit of no reply. But,

Fig. 129.—Pholas dactylus having hollowed out a shelter in a block of gneiss

while opposing unassailable reasons against the two theories, M. Quatrefages does not leave us without a reasonable explanation of a very puzzling phenomenon. "Let us not forget," he says, "that the interior of the gallery is constantly saturated with water; consequently all the points of the walls which are not protected by the tube are subjected to constant maceration. In this state a mechanical action, even though inconsiderable, would suffice to clear away the bed of fibre thus softened, and, if this action is in any degree continuous.

it suffices to explain the excavation of the galleries, however extensive their ramifications. Again, the upper cutaneous folds, especially the cephalic hood, having the power of expanding at will by an afflux of blood, being covered with a thick coriaceous epidermis, and moved by four strong muscles, seems to me very capable of performing the operation. It appears very probable that it is this hood which is charged with the removal of the woody fibre, rendering it incapable of resistance by previous maceration, which may also be assisted by some secretion from the animal." That the fleshy parts of the mollusc, acting upon the surface, softened by long maceration in water, is the true boring implement employed by the Teredo, is, probably, the only explanation the case admits of; at all events, in the present state of our knowledge, the explanation of this naturalist is the most reasonable which can be given.

Fig. 130.—Pholas dactylus (Linnæus).

The engraving (Fig. 129) represents *Pholas dactylus*, which has hollowed itself a home out of a block of gneiss. This dwelling is a cell just deep enough to contain the animal and its shell (Fig. 130). To excavate its cell at the bottom of one of these gloomy retreats seems to be all that the animal lives for. To ascend to the summit or sink to the bottom of their narrow house makes up all the accidents of existence to these strange creatures: the hole they dig is at once their dwelling and their grave; which fact is attested both by the rocks of the past and the present.

In its structure the shell of this genus differs notably from other Acephalous Molluscs, which led Linnæus to place it in a section which he made of multivalve shells. Between the two ordinary valves, in short, this shell presents certain accessory pieces, smaller than the true valves, and placed near the hinge, as represented in *Pholas dactylus* (Fig. 129), pieces which would not be there without a purpose.

The shell is equivalve, gaping on each side, swelling below, very

thin, transparent, and white. The animal has a thick, white, elongated, fleshy body; its mouth opening anteriorly, throws out a long tube traversed by two canals or siphons, through one of which the water necessary for the respiration of the animal is absorbed, and ejected through the other. Through another opening in the mantle a very thick and short foot is protruded.

In three ways also has this creature's method of boring been accounted for—the mechanical, the chemical, and the electrical; the first being the one generally held. In this case it is supposed that the animal uses its foot as a boring tool. The second presumes on the Pholas secreting an acid which corrodes the rock; the third that it possesses

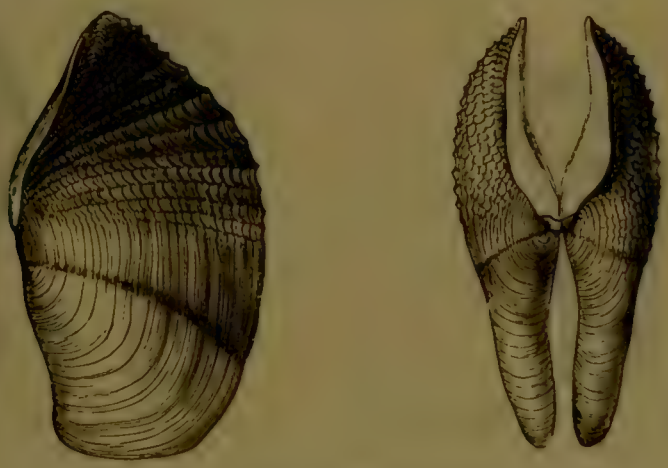


Fig. 131.—Pholas crispata (Linnæus).

a galvanic battery with similar powers. It is not impossible but that all these three theories may have a measure of truth. That the foot of the borer is used is clear. The luminosity which is so characteristic of the animal is in favour of an electric current, which is almost always accompanied by chemical decomposition, which would set free the hydrochloric acid of the sea water. The small size of the entrance to the chambers of the Pholas is accounted for by the increase of its size during its residence there. De Blainville thought that a simple movement of the shell incessantly repeated would suffice to pierce the stone, macerated by the sea water which passed through the breathing apparatus.

Mr. Robertson, of Brighton, exhibited the living Pholas in the act of boring through masses of chalk, and thinks the process entirely

effected by the simple mechanical action of the "hydraulic apparatus, rasp, and syringe."

"If you examine the living molluscs," says Gosse, "you will see that the fore part of the shell, where the foot protrudes, is set with stony points arranged in transverse and longitudinal rows, the former being the result of elevated ridges, radiating from the hinge, the latter that of the edges of successive growths of the shell. These points have the most accurate resemblance to those set on a steel rasp in a blacksmith's shop. The animal," Gosse adds, "turns in its burrow from side to side when at work, adhering to the interior by the foot, and therefore only partially rotating to and fro. The substance is

Fig. 132.—Pholas papyracea (Solander).

Fig. 133.—Pholas melanoura (Sowerby).

abraded in the form of a fine powder, which is gradually ejected from the mouth of the hole by contraction of the efferent siphon."

The Pholads are met with on every sea-shore, and are plentiful in the Channel; on the French coast they are called *Dails*, and sought for for their fine flavour. As examples of the genus, we may quote *Pholas dactylus* (Fig. 130); *Pholas candida*, found in the Channel and in the Atlantic Ocean, which lives buried in the mud or in decayed wood; *Pholas crispata* (Fig. 131), also found in the Channel; *Pholas papyracea* (Fig. 132); and *Pholas melanoura* (Fig. 133).

The bodies of many genera of Mollusca have the property of shining in the dark, but none emit a light more brilliant than that of the Pholads. Those who eat the Pholads in an uncooked state (which is by no means rare, for the flavour of the mollusc does not

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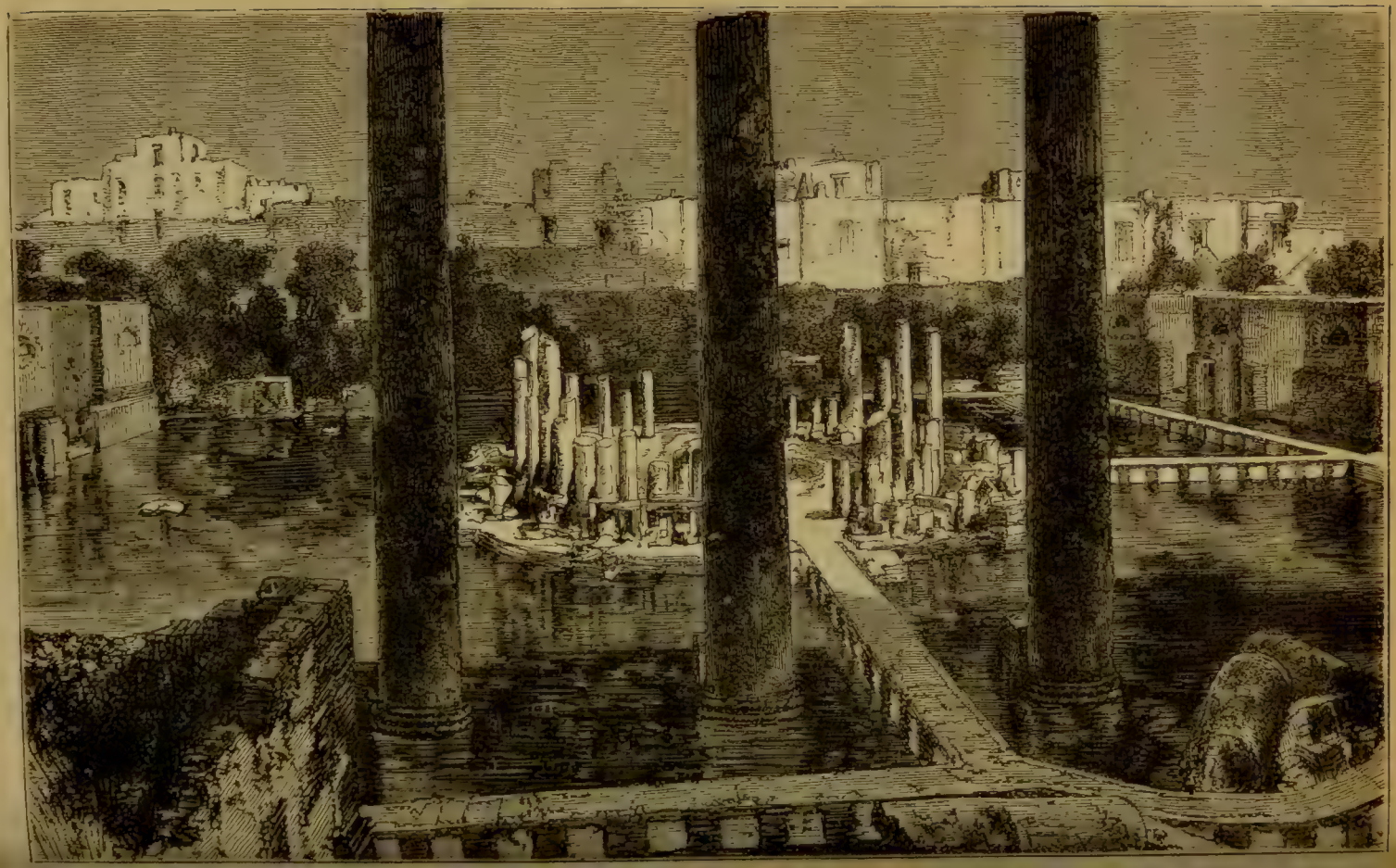


require the aid of cooking to render it palatable) would appear in the dark as if they had swallowed phosphorus; and the fisherman who, in a spirit of economy, supped on this mollusc in the dark, would give to his little ones the spectacle of a fire-eater on a small scale.

The perforations produced in stone by the Pholads have become important evidence in a geological point of view. In many countries there are evident signs of a considerable past sinking and then upheaval of the earth. But in no place is the evidence of this clearer than in a monument of high antiquity on the Pozzuolan coast, known as the Temple of Serapis (PLATE XI.).

In speaking of the culture of oysters by the Romans we shall have occasion to mention the disappearance of the Lucrine Lake, and its replacement by an enormous mountain, the Monte Nuovo. Now, Pozzuolo is situated at the foot of Monte Nuovo. We need not add that the whole neighbourhood is volcanic. Pozzuolo touches on the Solfaterra, on the Lake Avernus, and is not far from Vesuvius; and in the bay is the monument of other days, erroneously called the Temple of Serapis. In reality it was most probably a thermal establishment, established for its mineral waters, although the world has now agreed to call it a temple.

However that may be, the building has been nearly levelled by the hand of Time, aided by the hand of man; and the ruins now consist of three magnificent marble columns of about forty feet high. But the curious and important fact is, that these three columns, at about ten feet above the surface, are riddled with holes, and full of cavities bored deeply into the marble, and these borings occupy the space of about three feet on each column. The cause of these perforations is no longer doubtful. In some of the cavities the shell of the operator is still found, and it seems settled among naturalists that it belongs to a species of Pholas, although M. Pouchet, a naturalist of Rouen, denies this. "As far," he says, "as I have been able to judge from the fragment which I extracted from this temple, which is destitute of the hinge, it is infinitely more probable that this mollusc is a species of the genus *Coralliophaga*." In spite, however, of M. Pouchet's scepticism, the mass of evidence is opposed to his theory.

There are two modes of explaining the fact to which we have called attention. To enable the stone-boring molluscs, which live only in the sea, to excavate this marble, the temple and columns must have been buried several fathoms deep in sea-water. It is only in these conditions that the borers could have made burrows into, and laboured at their ease, in the marble columns.

But since the same traces of perforation are now visible ten feet

above the surface, it follows that, after being long immersed under water, the columns have been elevated to their present position. The temple has been restored to its primitive elevation, carrying with it, engraved in the marble, ineffaceable proofs of its immersion. Sir Charles Lyell has devoted a long chapter to the successive sinking and elevation of this temple, where the fact is most conclusively proved.

Fig. 134.—Aspergillum vaginiferum (Lamarck).

The second family of the Gastrochænidæ is a somewhat heterogeneous one, as it contains the genera Saxicava and Aspergillum. We have only space for a short account of the latter genus. *A. vaginiferum* has received the strange name of the Watering-Pot, and is represented in Fig. 134. It inhabits a calcareous tube, thick, solid, of considerable length, and nearly cylindrical, presenting at one extremity an opening fringed with one or many foliaceous folds in the form of frills, and at the other extremity a convex disc, pierced with holes like a watering-pot, whence its name. The animal is attached by certain muscles to the interior of the tube. Chenu, to whom we are indebted for our information respecting this curious mollusc, tells us "that the animal which inhabits this curious shell was first described by Russell, whose account of it is deficient in the anatomical details, which might explain the utility of the holes in the disc of the central fissure, and of the spiriform tubes found there." We suppose that this arrangement is necessary in order to facilitate respiration; and M. de Blainville thinks the small tubes are intended for the passage of the muscles which are necessary to fix the animal to the body on which it is to live, and in such a manner as to admit of its movements round a fixed point.

The animal which inhabits the *Aspergillum* is elongated, contractile, and only occupies the upper part of the tube, but it can stretch itself out sufficiently for all its wants. Shells of this genus are rare, although a great number of species are known. They are found in the Red Sea, and in the seas of Australia and Java. The shells are generally of a white or yellowish tint; some

have the tube covered with a glutinated sand, mixed with small fragments of shells of diverse colours. We know nothing of their habits, and their singular forms have left naturalists in doubt as to the place which should be assigned to them. It is only after having recognised the existence of two valves, which were detected with great difficulty just under the disc, and forming part of the sheath in which the animal is encased, that it has been decided to range them with the Gastrochœnidæ, and with the shells presenting an arrangement analogous and equally singular. These molluscs are, as M. Chenu says, little known, rare, and hence much sought for by collectors. They are exclusively exotic, the most common species being from Java. It is imported into Europe by the Dutch. A third family, the Anatinidæ, includes such genera as Myochama, Pandora, Lyonsia, Myacites, Pholadomya, Thracia, and Anatina, genera which were more important in the former than in the present seas; some, in fact, being wholly extinct, or represented, as in Pholadomya, by but one living species. A fourth family, the Myacidæ, including Glycimeris, which is found only in America; Panopæa, now for the most part extinct, Thetis, Neæra, Corbula, and Mya.

A fifth family, Solenidæ, contains the Solens, which under the name of "razor-fish" are so abundant on the sandy shores of all parts of the globe. These molluscs live with their shells buried vertically in the sand, a short distance from the shore; the hole which they have hollowed, and which they never quit, sometimes attains as much as two yards in depth; by means of their foot, which is large, conical, swollen in the middle, and pointed at its extremity, they raise themselves with great agility to the entrance of their burrow. They bury themselves rapidly, and disappear on the slightest approach of danger.

When the sea retires, the presence of the Solen is indicated by a small orifice in the sand, whence escape at intervals bubbles of air. In order to attract them to the surface, the fishermen throw into the hole a pinch of salt; immediately the sand becomes stirred, and the animal presents itself just above the point of its shell. It must be seized at once, for it disappears again very quickly, and no renewed efforts will bring it to the surface a second time. Its retreat is commonly cut short by a knife being passed below it; for it burrows into the ground with such velocity that it is difficult to capture it with the hands alone.

This shell has by some been compared to a knife-handle; by others to a razor, which has become its popular name. It is a thin, transparent, long, and slender equivalved bivalve, with parallel edges,

gaping and truncated at both extremities. The tints are rose-coloured, bluish-grey, and violet; the valves are generally covered with an epidermis of a greenish brown.

The animal which lives in this elegant dwelling has the form of an elongated cylinder. Its mantle is closed in its whole length, and only open at the ends at one side for the passage of the food to the mouth, and at the other for the passage of a tube formed of the two siphons united together. This curious shell, various species of which are presented in PLATE XII., is known as razor-fish, sabre-fish, and other names, which in some respects indicate the peculiar form and appearance of the shell.

The Tellinidæ, the sixth family in our table, is very important, as including a vast number of genera and species, of which, as types, we

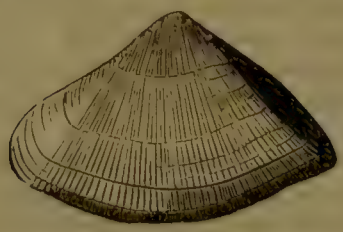


Fig. 135.—Donax rugosus (Linnæus).

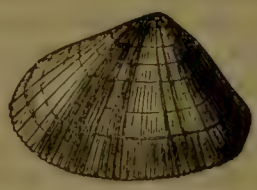


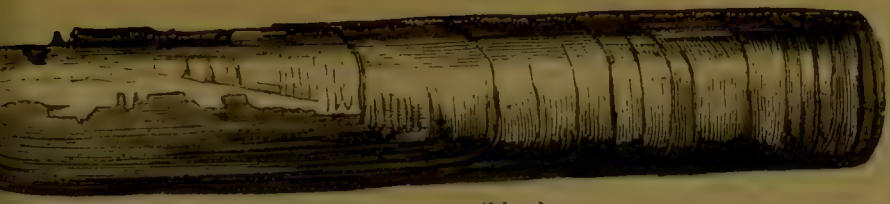
Fig. 136.—Donax denticulatus.

will particularise Tellina and Donax; but Galatea, Mesodesma, Semele, Sanguinolaria, Psammobia, and Capsula, are also important genera.

Along the shores of the Channel and in the Mediterranean there are few bivalves more abundant than the several species of the genus *Donax*. They live near the shore in shallow water, burying themselves perpendicularly in the sand. They have the very singular habit, considering their apparent helplessness, of being able to leap to a certain height and then project themselves ten or twelve inches. This may often be witnessed in the case of individuals left by the retreating tide. If seized by the hand, and attempts are made to disengage them from the sand, they continue to impress on their shell a sudden and energetic movement, aided by the elasticity of their foot, which is at once decisive and angular.

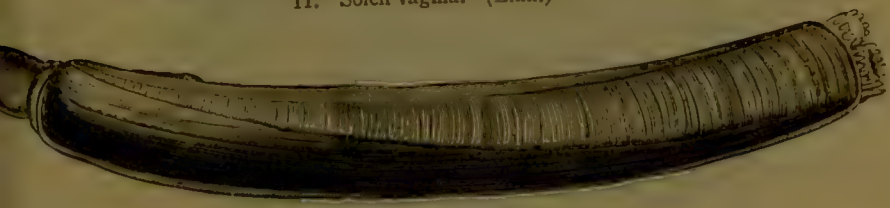
The shell of the genus *Donax* is nearly triangular in shape, compressed, longer than broad, regular, equivalve, not equilateral; the hinge with three or four teeth on each valve.

The animal is slightly compressed, and more or less triangular.

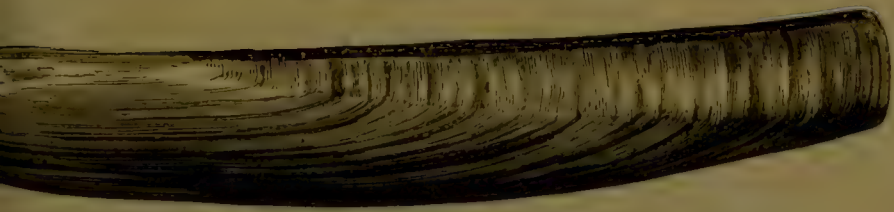


I. Solen siliqua. (Linn.)

II. Solen vagina. (Linn.)

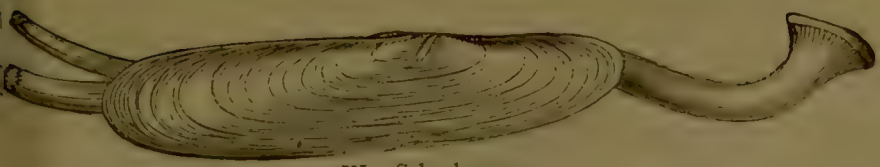


III. Solen ensis. (Linn.)



IV. Solen ensis major. (Lamarck.)

V. Solen ambiguus. (Lamarck.)



VI. Solen legumen.

XII. Razor-fish (*Solenidæ*).

Its mantle, which forms two symmetrical lobes enveloping the body, is open pretty nearly in all its extent, but it is united posteriorly, and terminates in two siphons, or nearly equal tubes, as in Fig. 127,

Fig. 137.—Tellina radiata (Linnæus).

p. 320. One of these tubes serves the purpose of respiration: it is the respiratory siphon. The other, serving the purpose of ejecting the products of digestion and the used-up water, is termed the excurrent siphon. The tentacles of the respiratory siphon seem to be

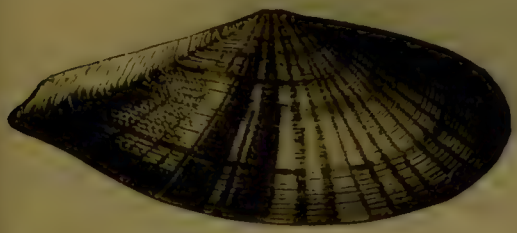


Fig. 138.—Tellina virgata (Linnæus).

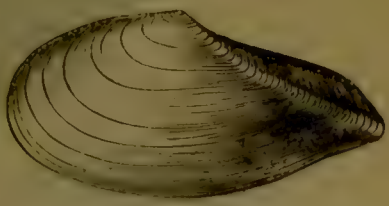


Fig. 139.—Tellina sulphurea (Lamarck).

possessed of exquisite sensibility. When touched, the animal draws in its siphon, and only puts it forth anew when the danger has passed. The species of *Donax* are very numerous, especially in the Asiatic and American seas. Among the European species we may mention *Donax rugosus* (Fig. 135) and *Donax denticulatus* (Fig. 136).

Next to *Donax* comes the genus *Tellina*, which includes many species of both small and large shells, all remarkable for their beauty of form, and for their brilliant and varied colours. One of these, called the rising sun (*Tellina radiata*), is represented in Fig. 137.

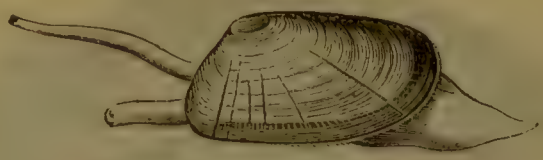


Fig. 140.—Tellina donacina (Linnæus).

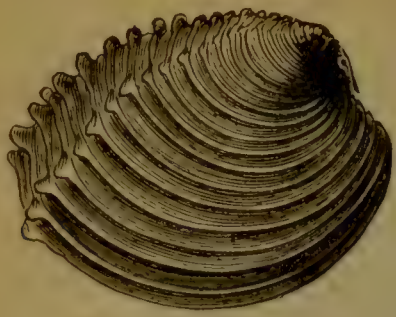
The Tellinas are found in every sea; the French coast furnishes many species: such as *Tellina virgata* (Fig. 138) and *Tellina sulphurea* (Lamarck), Fig. 139. In Fig. 140 *Tellina donacina* is represented with its two tubes or siphons.

The seventh family, or Mactridæ, includes Lutraria and Mactra.

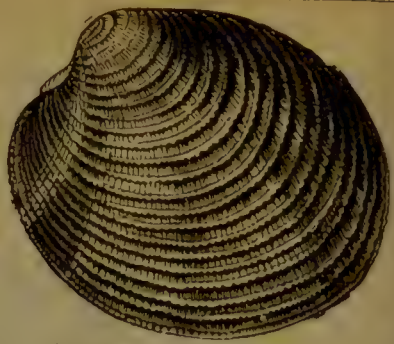
Fig. 141.—Venus verrucosa (Linnæus).

They are widely distributed genera, and there are several British species of both.

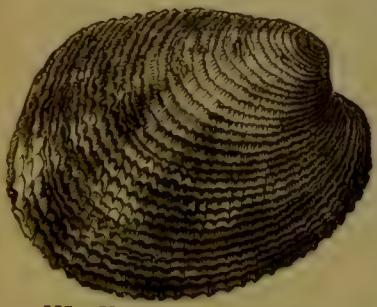
The eighth family, Veneridæ, includes Venus, Cytherea, Meroe, and Artemis; beautiful genera, and as such called by Linnæus and his followers after heroines of Greek mythology; Petricola, Venerupis,



I.—Venus plicata (Gmel.).



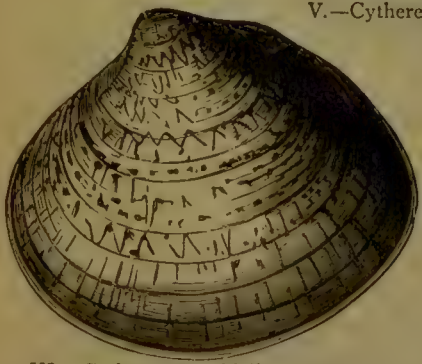
II.—Venus puerpera (Linn.)



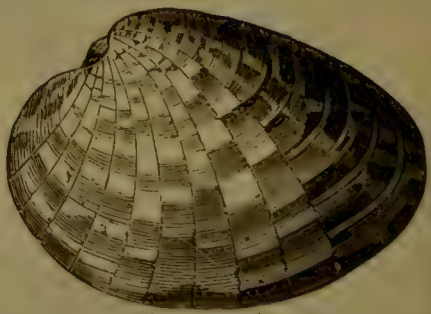
III.—Venus reticulata (Linn.)

IV.—Venus gnidia (Broderip).

V.—Cytherea zonaria (Lamarck).



VI.—Cytherea petechialis (Lamarck).



VII.—Cytherea maculata (Linn.).

XIII.—Venus and Cytherea.

Tapes, Lucinopsis, and Trigona, also belong to the family. These inhabit every sea; they are found in every region of the globe, more than 150 species being known. In most the shell is elliptic in form, the valves either smooth, warted, striated, spiny, or lamellous, some like those of Cardium and Donax. Like these, too, they bury themselves in the sand.

Among the vast number of species, many of them are extremely rare, and much sought after by collectors in consequence of their great beauty. In the principal ports of France, *Venus verrucosa* (Fig. 141), and another species known in the south of France under the name of Clovisse, are eaten there like oysters. Prepared with fine herbs, the Clovisse, we have M. Figuier's authority for saying, is not to be

Fig. 142.—Cytherea geographica (Chemnitz).

despised. "We may be believed also," he says, "if we add that nothing is more delicious than to eat the living Clovisse torn from the rock of the Phara of Lake Thau, when the Mediterranean sun of a day in winter is shining down upon us, the heart rejoicing in manhood's strength." In PLATE XIII. some of the principal species are represented, along with some of the more remarkable species of Cytherea. In Fig. 142 we have the elegantly-pencilled shell of *Cytherea geographica*, together with the animal, both drawn from Nature.

The sub-section we shall now treat of is without the pallial line sinuated. The Cyprinidæ form the ninth family of our arrangement, and contain the genera Cardita, Cypricardia, Isocardia, Crassatella, Astarte, Circe, and Cyprina, which contain among them some hundred species.

The Cycladidæ are our tenth family, and include Cyrenoides, Cyrena, Pisidium, and Cyclas.

The Lucinidæ is the eleventh family, containing Galeomma, Lepton, Montacuta, Kellia, Diplodonta, Corbis, and Lucina.

The twelfth family, Cardiadæ, contains the familiar cockles, belonging to the genus Cardium, which is derived from καρδία, *a heart*, which they are supposed to resemble in form: they are amongst the most widely-distributed of shells. The shell is convex, as we see in *C. hians* (Fig. 143), somewhat heart-shaped, equivalved, the edges dentate or corrugated, the hinge furnished with four teeth upon each valve. The accessary ornamentation varies with the species, some being smooth, as in *Cardium groenlandicum*, Chemnitz (Fig. 144); others, and by far the greater number, are furnished with regular ripples,

Fig. 143.—Cardium hians (Brocchi).

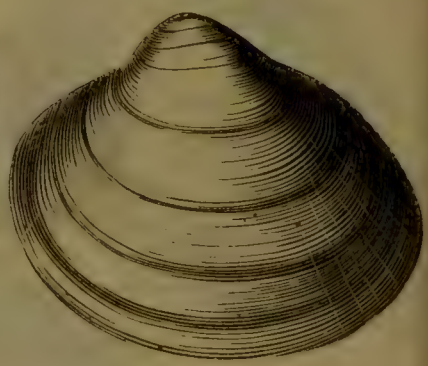


Fig. 144.—Cardium groenlandicum (Chemnitz).

generally obtuse, sometimes in ridges diverging from the point and armed with straight or curved spines, arranged in the oddest manner, as in *Cardium aculeatum* (Fig. 145).

In the genus Cardium, as well as Donax, Tellina, and Venus, the respiratory organs are somewhat modified, so as to adapt them to the habits of the animal. All these molluscs live buried in the sand, and the two siphonal tubes, issuing from the interior of their bodies to bring the atmospheric air into communication with their respiratory organs, are usually very short.

In *C. hians* (Fig. 143) the mantle has a large opening in front, fringed anteriorly with papillæ in the form of tentacula; the inhabitant of the shell has a very large foot; its mouth is transverse and funnel-shaped, and furnished with labial appendages. One of the

peculiarities in the organisation of these molluscs is in direct connection with their mode of life. For those molluscs, which most commonly live on the sea-shore, and bury themselves in the sand to the depth of four or five inches, are enabled to breathe, to draw water for their nourishment, and also to throw off the products of digestion, by having the mantle prolonged, as we have seen, into two tubes, the orifices of which reach to the surface of the mud. By means of their foot, which is an extremely curious organ of locomotion, the Cockles can at will issue from their holes and re-enter them. The fishermen of the shore easily recognise the presence of these animals by the little jets of water which they throw up through the sands.

Fig. 145.—Cardium aculeatum (Linnæus).

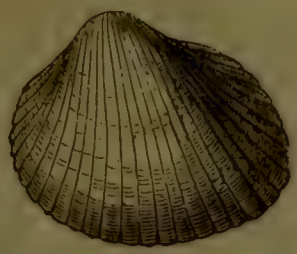


Fig. 146.—Cardium edulis (Linnæus).

These molluscs are found in every sea on the globe, and under all latitudes. Many of them belong to our own and the French coasts, where they are eagerly sought for by collectors, as well as for food. The flesh of the animal, however, is somewhat leathery, and little esteemed. The species most common on the littoral of the Atlantic is *Cardium edulis* (Fig. 146), its white or fawn-coloured shell being hollowed out into six-and-twenty furrows, forming so many corrugated ripples on its side. It is considered good for food.

The common cockle frequents sandy bays, near low water. It is sometimes met with in brackish water, as at the mouth of the Thames.

Cardium costatum (Fig. 147) is an exotic species which inhabits the coast of Guinea and the Senegal, the shell of which, white and fragile, is much sought after by collectors.

The thirteenth family of our list, Tridacnidæ, contains the genus Tridacna, with only eight species, but it contains the largest of all bivalve shells. The historian of the wars of Alexander the Great speaks of oysters inhabiting the Indian Ocean which were more than a foot long; these were probably *Tridacna*, the shells of which were most likely to be seen by the Macedonian conquerors. The valves of *Tridacna gigas* are sometimes found a yard and a half in length, and weighing 500 pounds. Magnificent examples may be seen in the church of Saint Sulpice, Paris, where they hold the holy water. These beautiful shells were the gift of the Venetian Republic to Francis I. Under Louis XIV., the curé Languet had them

Fig. 147.—Cardium costatum (Linnæus).

presented to the church of Saint Sulpice, where they are used as basins for holy water. Another pair are exhibited in the church of Saint Eulala, at Montpelier, but much smaller in size. The shells of *Tridacna gigas* are formed, as represented in PLATE XIV., of three acute angles, festooned on their edges by broad sides bristling with deep white scales. The hinges have two teeth; the ligament is elongated and external.

The animal of *Tridacna* is remarkable for its fine colours. *Tridacna serrifera* is of a beautiful blue round the edges of the mantle, rayed through a shade of very pale blue; more in the interior of the mantle is a row of small ocelli of a yellowish green; the centre is a bright violet, with brownish longitudinal punctured lines. "We have at this moment before our eyes," say the travellers Quoy and Gaimard, "one of the most charming spectacles that can be seen,

XIV.—Tridacna gigantea.—Holy Water Basin in the Church of Saint Sulpice at Paris.

when at a little depth beneath the surface a number of these animals display the brilliant velvety colours and varying shades of their submarine parterres. As we can only perceive the gaping opening of the valves, we may imagine to ourselves what is its entire aspect." The mantle of the animal is closed and ample; its edges are swollen, and reunited in nearly its whole circumference in such a manner as to leave only three very small openings—two in the upper part; the one serves the purpose of discharging the products of digestion, the other gives entrance and exit to the water necessary for respiratory purposes. The third opening is in the lower part of the body, and free; it leaves an opening for the passage of the foot, which is enormous, and is surrounded with an ample tuft of byssoidal fibres.

Fig. 148.—Tridacna squamosa (Lamarck).

Aided by this silky tuft, the animal attaches itself to the rocks, and suspends its weighty shell from them. If it is intended to remove those attached to the sides of the rock, it is necessary to cut the cords of the tendonous byssus by which it is held suspended with a hatchet.

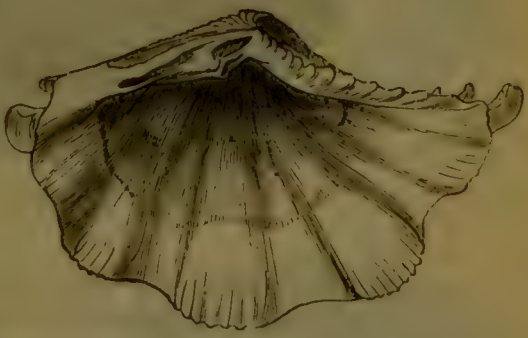


Fig. 149.—Tridacna squamosa, on the inside (Lamarck)

All the species are inhabitants of the tropical seas. The *Tridacna gigas* is a native of the Indian Ocean. The flesh, though leathery and by no means of an agreeable flavour, is a great resource to the poor Indians. The accompanying representations of *Tridacna squamosa* (Figs. 148 and 149) will convey a general idea of the genus.

The fourteenth family, Hippuritidæ, is entirely fossil; but the fifteenth, Chamidæ, of which the best example is the typical genus Chama, is widely distributed in tropical seas.

The very numerous division of shells called Asiphonida possesses animals without respiratory siphons. To it belong the shells we shall now describe. The sixteenth family, Unionidæ, contains the genera Iridina, Anodon, and Unio.

The pond mussels, *Anodonta*, are found in lakes, rivers, and seas of North America, Europe, and Siberia. Their shells are rounded or oval, generally very thin, regular, and equivalve, not gaping, the hinges without teeth, whence their name, from the Greek, ανόδόντος, *without teeth.* These shells are nacred inside, and generally smooth.

Fig. 150.—Unio littoralis (Cuvier).

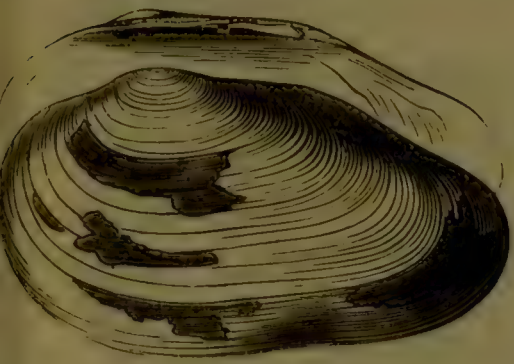
The *Anodonta cygnea* (Fig. III., PLATE XV.) is broad, deep, and light; it is sometimes employed for skimming the cream off milk. The genus is divided into many groups, the principal forms of which are represented in PLATE XV.

The genus *Unio* (river mussel) has a wider distribution than Anodonta, and is found in the muddy bottoms of rivers in all the great continents. The animal resembles that of Anodonta, but the shell presents a toothed hinge. The lower face of the valve is nacreous, but shaded with purplish violet, and iridescent; the anterior face is of a green colour, which varies from a light to a blackish green.

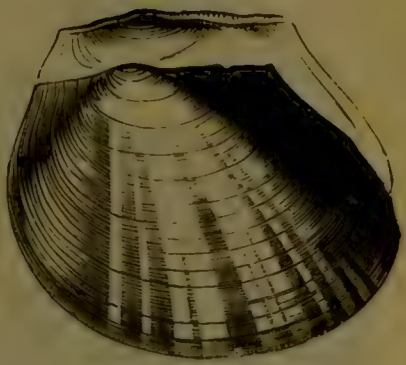
Among the species found in European rivers may be noted the

I.—Anodonta angulata (Lea).

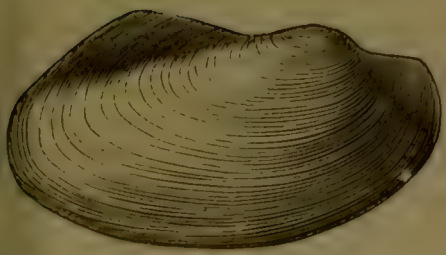
II.—Anodonta ensiformis (Spix).



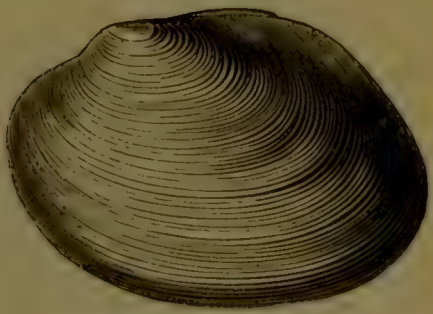
III.—Anodonta cygnea (Linn.).



IV.—Anodonta magnifica (Lea).



V.—Anodonta anserina (Spix).



VI.—Anodonta latomarginata (Lea).

XV.—Anodonta.

Rhine mussel, a large species, the nacre of which is employed for ornamental purposes. *Unio littoralis* (Cuvier), is represented in Fig. 150, and *Unio pictorum*, Fig. 151. The flesh of the river mussels is leathery, of an insipid taste, and scarcely eatable: the finest species are found in the great American lakes and rivers.

Fresh-water mussels, as we have seen, produce pearls of moderate value. Linnæus, who was aware of the origin of the Pintadine pearls, and of pearls in general, was also aware of the possibility of producing them artificially from various molluscs. He suggested bringing

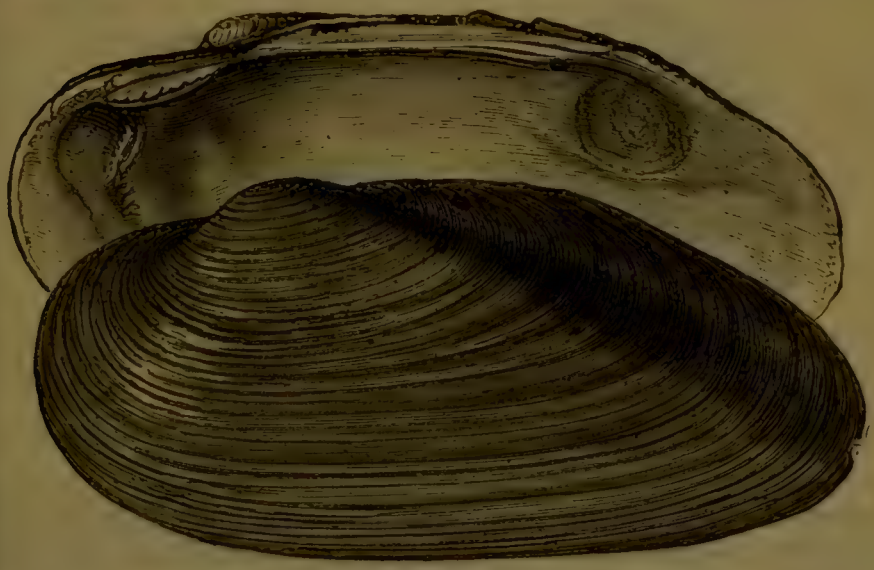


Fig. 151.—Unio pictorum (Linnæus).

together a number of mussels, piercing holes in their shells with an auger in order to produce a wound, and afterwards leave them for five or six years, to give the pearl time to form. The Swedish Government consented to try the experiment, and long did so in secret; pearls were produced, but they were of no value, and the enterprise was abandoned as unsuccessful.

Scottish pearls were much celebrated in the middle ages; and between the years 1761 and 1784 pearls to the value of £10,000 were sent to London from the rivers Tay and Isla; "and the trade carried on in the corresponding years in the present century," says Mr. Bertram, "is far more than double that amount." The pearl,

according to Mr. Bertram, is found in a variety of the mussel, which is characterised by the valves being united by a broad hinge, and having a strong fibrous byssus, with which it attaches itself to other shells, to rocks, and other solid substances. "The pearl fisheries of Scotland," he adds, "may become a source of wealth to the people living on the large rivers, if prudently conducted." Mr. Unger, a dealer in gems in Edinburgh, having discerned the capabilities of the Scotch pearl as a gem of value, has established a scale of prices which he gives for them, according to their size and quality; and it is now a fact that the beautiful pearls of our Scottish streams are admired

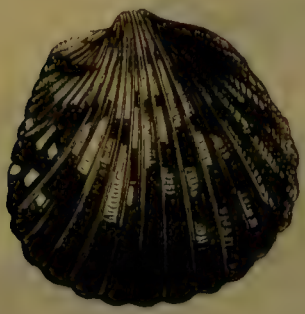


Fig. 152.—Pectunculus aureflua (Reeve).

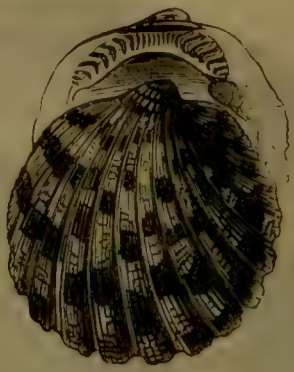


Fig. 153.—Pectunculus Delessertii (Reeve).

beyond the Orient pearl. Empresses and queens, and royal and noble ladies, have made large purchases of these gems; and Mr. Unger estimates the sum paid to pearl-finders in the summer of 1864 at £10,000. The localities successfully fished have been the classic Doon, the Forth, the Tay, the Don, the Spey, the Isla, and most of the Highland rivers of note. Scottish pearls are much whiter in colour than Oriental. What tint they have is bluish, while those of the East are yellowish. Pink pearls are produced by several exotic species of Unio.

The seventeenth family is that of the Trigoniadæ, with the genus Trigonia, of which so many species occurred in the Jurassic period in the strata of Europe, but of which two or three alone are now left alive in the seas of Australia.

The eighteenth family, the Arcadæ, affords between 200 and 300 species of the genera of Leda, Nucula, Pectunculus, and Arca. Of these we shall only at present instance Pectunculus.

Species of the genus *Pectunculus* are abundant on the shores of the Mediterranean and along the Atlantic coast. If we take up at hazard a handful of shells on any part of the French coast, one-third will consist of *Pectunculus*. They are found mixed with species of the genera *Cardium*, *Venus*, *Solen*, and *Pecten*. Their round and robust frame attracts much attention. They form the first of those charming infantile collections which are gathered at our mother's feet.

The animal which inhabits this pretty shell is moulded on its

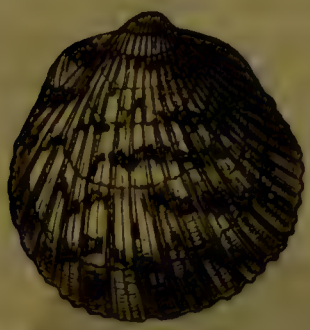


Fig. 154.—Pectunculus pecteniformis (Lamarck).

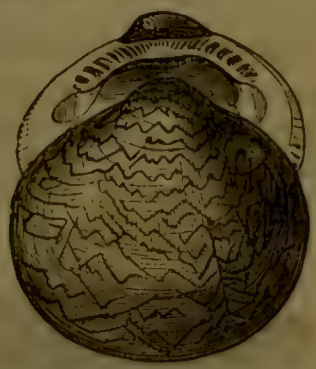


Fig. 155.—Pectunculus scriptus (Born).

curvature; like the shell, it is round and squat; it is furnished with a mouth, large, and thick for its size, and with branchiæ. When the animal is taken alive, it sometimes exudes a thick mucous liquid over the shell, which has disgusted many a young collector with his capture.

Among numerous species of *Pectunculus* we note as worthy of representation: *P. aureflua*, Reeve (Fig. 152); *P. Delessertii*, Reeve (Fig. 153); *P. pecteniformis*, Lamarck (Fig. 154); and *P. scriptus*, Born (Fig. 155).

CHAPTER XII.

ACEPHALOUS MOLLUSCA—(*continued*).

MYTILIDÆ—THE MUSSEL FAMILY.

"Ecce inter virides jactatur mytilus algas."—*Anthologia.*

We now come to consider the nineteenth family, that of Mytilidæ, which includes the genera called Mytilus, Modiola, Lithodomus, and Dreissena.

The well-known shell of the mussel (*Mytilus edulis*, Fig. 156) is

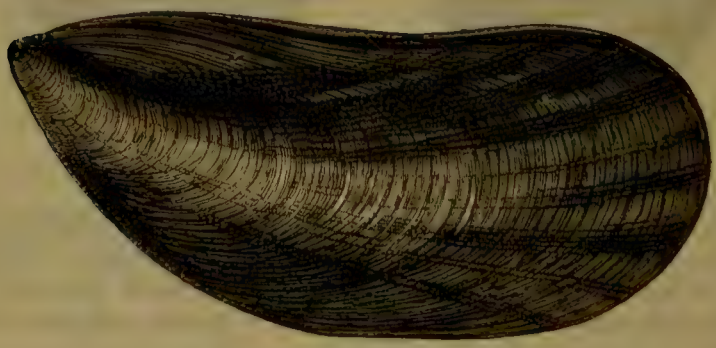


Fig. 156.—Mytilus edulis (Linnæus).

longitudinal, equivalve, and regular, pointed at the base, with capacity to attach itself by a byssus; the hinge has no teeth, but a deep furrow, in which the ligament is located. In the genus *Mytilus* the byssus is strong and coarse, and the palpi are long. In *Modiola* it is ample, but fine, and the palpi are triangular. In both these genera the foot is elongated and grooved, its retractile muscles numerous. In *Lithodomus* the byssus is rudimentary. In *Dreissena* the shell is like that met with in the genus *Mytilus*, but without its pearly lining.

The animal of *Mytilus edulis*, as described by M. Chenu, is

elongate, oval, the lobes of the mantle simple or fringed, divided at the edge into two leaves, the interior being very short, bearing fringes of very minute and constantly moving cilia; the exterior gill is united to the shell very near the edge. The opening by which water and food are introduced supplies the branchiæ at the same time. The stomach consists of a white membrane, thin, opaline, and presenting itself in longitudinal folds; the liver is granular, composed of greenish grains more or less deep, contained in the meshes of a whitish tissue forming a thickish bed, which surrounds the stomach, the intestines taking the direction of the median and dorsal line, and beneath the heart are received and terminate in a small appendage, floating in the cavity of the mantle near the hinge. The foot is, perhaps, the remarkable organ of the mussel—it is small, semi-lunar when not in motion, but capable of great elongation, resembling thus a sort of conical tongue having a longitudinal furrow on its side. It is put in motion by several pairs of muscles, all of which penetrate and are interlaced with the tissue; behind it is the silky byssus. The mouth is large, and furnished with two pairs of soft palpi, which are pointed and fixed by their summit. At the base of the foot is a gland which furnishes a viscous secretion; this viscous liquid is organised and moulded in the groove of the foot, and forms a thread, which originates the byssus; this latter is a bundle of viscid hairs, or threads, which holds on to its shell.

The byssus plays an important part in the organisation of the mussel. While the oyster remains entirely riveted to its rock, until torn from it by violence, the mussel moves about, and in this motion the byssus is an active agent. The mussel attaches its byssus to some fixed object, and drawing upon it, as upon a line, the shell is displaced. The house is drawn onwards; the animal is in motion. It takes no great strides, but a fraction of an inch satisfies its desires; it is, however, an advance upon the oyster, and a lesson in mechanics. The mussel stretches out its foot, and, at the point chosen, it fixes on a thread of the byssus; then, withdrawing the foot suddenly, and hauling in the thread, the animal and shell are moved forward. Every time it repeats this motion it seems to attach an additional thread, so that at the end of the four-and-twenty hours it has used many inches in length of cordage. In the byssus of some mussels we find as many as 150 of these small threads, with which the animal anchors itself most securely to the rock. Aided by this cordage, the mussel suspends itself to vertical rocks, holding on a little above the surface of the water, so that the shell is smooth and polished as compared with the coarse and rugged shell of the oyster.

The mussels, like the oysters, are gregarious, and widely diffused over all European seas. They abound on both sides the Channel, their lower price having procured for them the name of "the poor man's oyster;" but it is infinitely less digestible and savoury than its congener.

Many of our readers may think that mussels are found on the shore in a state of nature, of good size, well flavoured, and fit for the table. Nothing of the kind! Detached from the rocks and cliffs of

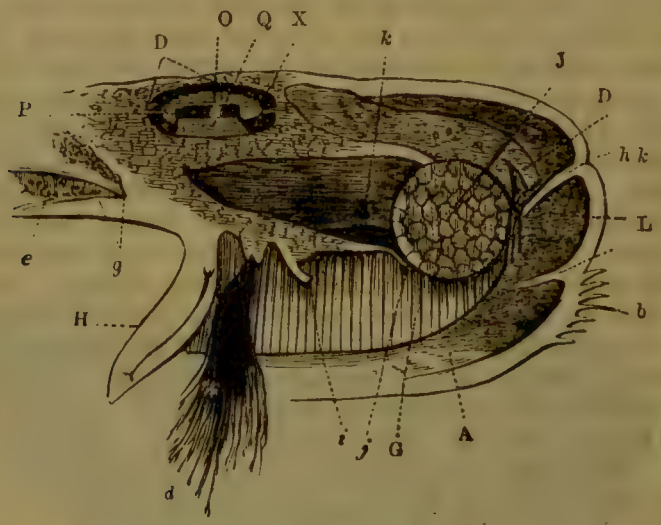


Fig. 157.—Byssus, mantle, and oviduct of Mytilus.

A, right lobe of the mantle; D, rectum; G, branchiæ; H, foot; J, posterior muscle; L, superior tube; O, heart; P, ventricle; Q, auricle; X, pericardium; *b*, tentacles; *d*, byssus; *e*, gland of the byssus; *g*, retractile muscle of the foot; *h*, valves of the mantle; *i*, oviduct; *j*, orifice of the excretory organ; *k*, internal ditto.

the sea, where it has been growing in a natural state, it is lean, small, acrid, and unwholesome food; and it is only when human industry intervenes to ameliorate this child of Nature that it becomes palatable and wholesome food. In order to trace the ameliorative process by which the leathery flesh of the mussel is rendered tender, fat, and even savoury, we must conduct the reader back into the middle ages.

Some time in 1236 a barque, freighted with sheep and manned by three Irishmen, struck upon the rocks in the creek of Aiguillon, a few miles distant from Rochelle. The neighbouring fishermen who came to the relief of the crew succeeded with great difficulty in saving the life of the master, a man named Walton. Exiled upon

the lonely shore of the Aunis, with a few sheep saved from shipwreck, Walton at first supported himself by hunting sea-fowl, which frequented the shore and neighbouring marshes in vast flocks. He was a skilful fowler, and invented or adapted a peculiar kind of net, which he called the *night net*. This consisted of a net some 300 or 400 yards in length by three in breadth, which he placed horizontally, like a screen, along the quiet waters of the bay, retaining it in its position by means of posts driven into the muddy bottom. In the obscurity of the night the wild fowl, in floating along the surface of the waters, would come in contact with the net, and get themselves entangled in its meshes.

But the Bay of Aiguillon was only a vast lake of mud, in which boats moved with difficulty; and Walton, having arranged his bird-net, began to consider what kind of boat would enable him most conveniently to navigate the sea of mud. The flat-bottomed, square-sided boat, known in our rivers as a *punt*, and on the Norman coast as an *acon*, was the result. Walton's boat had a wooden frame some three yards long and one in breadth and depth, the fore part of which sloped down into the water, in the form of a prow, at a slight angle. In propelling the boat the rower, who occupied the stern of the punt, knelt on his right knee (as represented in Fig. 158), inclining forward, with one hand on each edge, and the left leg outside the boat. A vigorous push with the left foot gave the frail boat an impulse, under which it rapidly traversed the bay from one point to the other.

The mussels swarmed in the little bay; and Walton soon remarked that they attached themselves by preference to that part of the post a little above the mud, and that those so placed soon became fatter, as well as more agreeable to the taste, than those buried in the mud. He saw in this peculiarity the elements of a sort of mussel culture which might become a new branch of industry. "The practices he introduced," says M. Coste, "were so happily adapted to the requirements of the new industry, that, after six centuries, they are still the rules by which the rich patrimony he created for a numerous population is governed. He seems to have applied himself to the enterprise, conscious not only of the service he was rendering to his contemporaries, but desirous that their descendants should remember him, for in every instance he has given to the apparatus which he invented the form of his initial letter W. After due consideration, Walton began to carry out his design. He planted a long range of piles along the low marshy shore, each pair forming a letter V, the front of the letter being towards the sea,

and each limb diverging at an angle of 45°. These posts were driven about a yard asunder; they were about twelve feet long, six feet being above water, and interlaced with branches wattled together, so as to form continuous hurdles, each about 200 yards long, which are called *bouchots*. By the assistance of this apparatus, which intercepted spat which would otherwise have been swept away to sea

Fig. 158.—Punt or Pirogue of the Marsh.

by the tide, Walton formed a magnificent collection of mussels; but he did not abandon his isolated piles. These, being without fascines or branches, and always submerged, arrested the spat at the moment of emission."

The advantages of this system of culture adopted by the Irish exile were so obvious, that his neighbours along the shore were not slow to imitate his example. In a short time the whole bay was

covered with similiar bouchots. At the present time these lines of hurdles form a perfect forest in the little creek. About 230,000 piles support 125,000 fascines, which, according to M. Coste, "bend all the year under a harvest which a squadron of ships of the line would fail to float." There are about 500 of these bouchots in the bay, each from 200 to 250 yards in length and six feet high.

The isolated piles are without palisades, and are uncovered only at spring tides. In the months of February and March the spat collected on them scarcely equals in size a grain of linseed; by the

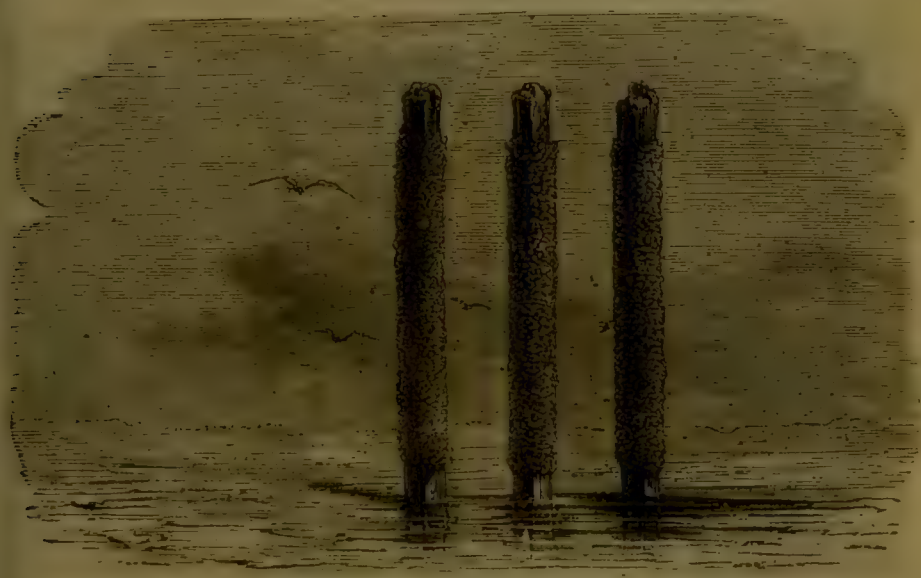


Fig. 159.—Isolated Piles covered with the Spawn of Mussels.

month of May it will be about the size of a split pea; in July, a small haricot bean: this is the moment for its transplantation. In this month the *bouchotiers*—as the men occupied in this culture are called—launch their punts, and proceed to the part of the bay where these piles are driven. They detach with a hook the agglomerated masses of young mussels, which they gather in baskets, and carry them to their bouchots. These bouchots, that is to say, the piles covered with fascines and branches, are of four different heights, forming, so to speak, four stages, according to the age and growth of the mussel. Each stage receives the mollusc suitable to it. In the first stage of its existence the mussel cannot endure exposure to the

air, and remains constantly under water, except at the period of spring tides. These are gathered in sacks made of old matting, or suspended in interstices of the basket-work. "These immense palisades," says M. Coste, "become covered with black clusters of mussels developed between the meshes of their tissues." At this time the second rows are cleared away to make room for younger generations; the mussels, which no longer dread the air, are transported to the more advanced bouchots, which remain above water in all tides, where they stay till they are fit for market, which usually

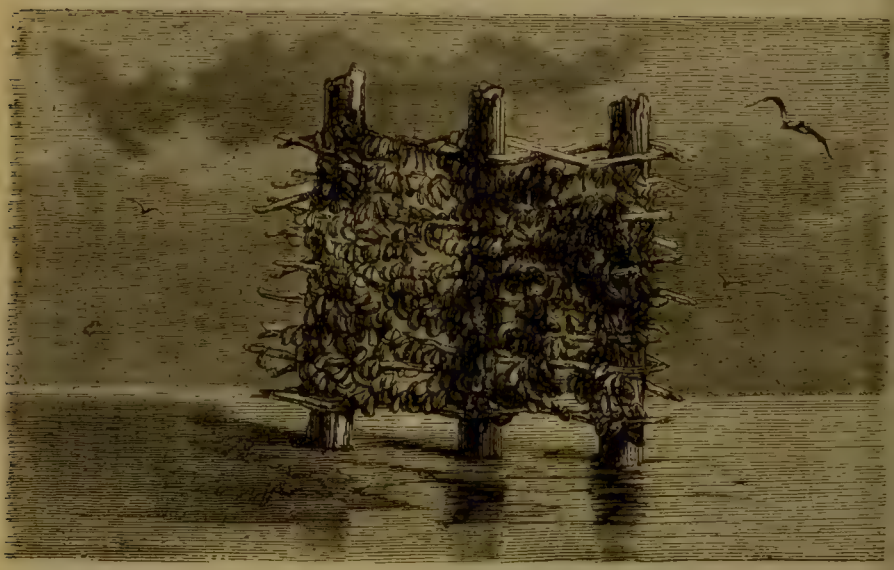


Fig. 160.—Piles, with Basket-work, covered with Mussels in a fit state to be gathered in.

happens after ten or twelve months of culture on the more advanced bouchots.

But, in order to prepare for this consummation, they are subjected to a second and even a third remove. There is no longer any danger in subjecting them to the air for many hours. From this they pass to a fourth stage, termed *Amont* (Fig. 160). From this stage the full-grown mussel is removed. Under this system of culture the reproduction, nursing, collecting, and preparing for market, are made simultaneously. From July to January the mussel trade is in full operation, and the flesh in perfection. From February to April is the close season; their flesh is then poor and leathery. It is also

remarked that those which inhabit the upper rows of the wicker-work are of a mellower flavour than those on the lower ranks, and that the intermediate rows are an improvement on those which are buried in the mud, although even these are preferable to mussels gathered on the sea-shore in a state of nature.

M. Coste gives a graphic description of the manner in which this industry is carried on. "Having supplied the neighbouring villages," he says, "for the purpose of supplying the more distant cities, the bouchotiers land their punts, filled with mussels, which their wives carry into grottoes hollowed out of the cliffs, where they clean and pack them in hampers, baskets, and panniers, for conveyance by carts or pack-horses. They depart on their respective journeys at night, so as to reach their markets at La Rochelle, Rochefort, Surgères, Saint-Jean-d'Angely, Angoulême, Niort, Poitiers, Tours, Angers, and Saumur, at an early hour. A hundred and forty horses and ninety carts make upwards of 33,000 journeys annually to these cities. Besides this, forty or fifty boats come from Bordeaux, the isles of Ré and Oleron, and from the sands of Olonne, making an aggregate of 750 voyages per annum, distributing the harvest of the little bay at places where horses could not serve the purpose.

"A bouchot, well furnished, supplies annually, according to the length of its wings, from 400 to 500 charges. The charge is 150 kilogrammes (over 300 pounds), and sells for five francs; a single bouchot thus carries a harvest equal in weight to 130,000 to 140,000 pounds, equal in value to £100; the whole bay probably yielding a gross revenue of £480,000. This figure, and the abundant harvest which produces it, gives only a slight idea of the elementary resources of the sea-shore; and every part of the coast, properly adapted for the purpose, could be turned to equal advantage. In the meantime, the Bay of Aiguillon remains a monument of what one man may accomplish."

While commending the mussel as an important article of food, we must not conceal the fact that it has produced in certain persons very grave effects, showing that for them its flesh has the effects of poison. The symptoms, commonly observed two or three hours after the repast, are weakness or torpor, constriction of the throat and swelling of the head, accompanied by great thirst, nausea, frequent vomitings, and eruption of the skin and severe itching.

The cause of these attacks is not very well ascertained; they have in turn been ascribed to the presence of the coppery pyrites in the neighbourhood of the mussel; to certain small crabs which lodge

themselves as parasites in the shell of the mussel; to the spawn of star-fishes or medusæ that the mussel may have swallowed. But, probably, the true cause of this kind of poisoning resides in the predisposition of individuals. The remedy is very simple: an emetic, accompanied by drinking plentifully of slightly acidulated beverages.

We have now come to the twentieth family, the Aviculidæ, which contains Avicula, Malleus, Meleagrina, Perna, and Pinna. The shells of the sub-genus Malleus (hammer-headed oysters) have a rough resemblance to the implement from which they derive their name. The

Fig. 161.—Malleus vulgaris (Lamarck).

valves are nearly equal, blackish, and somewhat wrinkled on the exterior, often brilliantly nacred in the interior. They are enlarged to the right and left of the hinge, forming prolongations on each side, which give them the fancied resemblance of a hammer-head (*Malleus vulgaris*, Fig. 161). At the same time they grow in a direction opposite to the hinge, which gives an appearance something approaching the handle of the implement.

This is the first feature which a glance at *Malleus alba* (Fig. 162) conveys. The hinge is without teeth, having instead a deep conical fossette or dimple, for the reception of a very strong ligament, which acts upon the valves. The animal is contained in the interior

of the shell, its mantle fringed by very small tentacular appendages. Only six actually living species of the genera are known, which are inhabitants of the Indian Ocean, of the Australian seas, and the Pacific Ocean.

The beautiful diaphanous nacre which embellishes the interior of so many ornamental cabinets is principally produced by the animal inhabiting the *Meleagrina margaritifera*, a bivalve, sometimes

Fig. 162.—Malleus alba (Lamarck).

designated the *Pintadine*, or mother-of-pearl shell. This bivalve moors itself to the bottom of the sea by a strong byssus of a brownish colour. The valves of the shells are irregularly rounded in their young days; they are externally lightly foliated, and ornamented with bands of green and white, which spring from the summit in rays, and afterwards break off into two or three slightly scattered branches. In old age they become rugged and blackish. The shell is in its perfection when about eight or ten years old, their size being then about six inches in diameter, with a thickness of about an inch and a quarter.

Nacre is the hard and brilliant substance with which the valves of certain shells are lined in the interior. This substance is white, silky, slightly azure, and more or less iridescent. Most of the bivalves are supplied with nacre; some of them even yield it of a blue, or blue and violet colour. The iridescent *Haliotis iris*, for instance, has a nacre of an emerald-greenish blue, changing colour with reflections of a purple violet. *Turbo argyrostomus* (Linnæus) presents a mouth of bright silvery hue, while *Turbo chrysostomus* appears in all the glory of gold; but the *Pintadine* yields the purest white nacre, as well as the most uniform, and especially the thickest. This product

Outside of the shell. Inside of the shell.
Fig. 163.—Meleagrina margaritifera (Linnæus).

owes its brilliant and delicate appearance to the play of light on it in its highly-polished state. For practical purposes the nacre is separated from the shell with an instrument; sometimes all the exterior part of the shell being dissolved away from the precious substance, leaving only the naked bed of nacre.

The pearl oyster (*Meleagrina margaritifera*), is the most interesting of all the nacre-bearing shells; the exterior as well as the interior of the shell is represented in Fig. 163. The interior of the shell affords the most exquisite pearls; the Esterhazy collection of jewels contains many magnificent specimens. This shell is nearly round, and greenish in colour on the outside; it furnishes at once the finest pearls, under favourable circumstances, and the nacre so useful in many industrial arts. Fine pearls and nacre have, in short, the same origin. The nacre invests the whole interior of the shell of *Melea-*

grina margaritifera; being the same secretion which in the pearl has assumed the globular form: in one state it is deposited as nacre on the walls of the bivalve, in the other as a pearl in the fleshy interior of the animal. This nacre is therefore at once a calcareous and a horny substance, which the animal secretes, and which it attaches to the interior walls of the shell during the several periods of its development. Pearls are formed of the same substance, only in place of being deposited upon the valves in beds, the material is condensed and agglomerated in small spheroids, which develop themselves either on the surface of the valves or in the fleshy part of the mollusc.

Fig. 164.—Meleagrina margaritifera (Linnæus).

Between nacre and pearls, therefore, there is only the difference of the form of deposition. Fig. 164 represents the pearl oyster with calcareous concretions in various states of progress.

The finest pearls—solidified drops of dew, as the Orientals term them in the language of poetry—are secretions of nacrous material supposed to be spread over foreign bodies which have accidentally got beneath the mantle of the mollusc. The matter, in place of being spread over the surface of the valves in their beds, is condensed either on the centre of the valves or in the interior of the organ, and forms a more or less rounded body. The pearls, when deposited on the valves, are generally adherent; those which originate in the body of the animal are always free. Generally we find some small foreign body in their centre which has served as a nucleus to the concretion, the body being perhaps a sterile egg of the mollusc, the egg of a fish,

a grain of sand even, round which has been deposited in concentric layers the beautiful and much-prized gem.

The Chinese, and other Eastern nations, are said to turn this fact in the natural history of this bivalve to practical use in making pearls and cameos. By introducing into the mantle of the mollusc, or into the interior of its body, a round grain of sand, glass, or metal, they induce a deposit which in time yields a pearl, in the one case free, and in the other adhering to the shell. In some cases pearls are said to be produced in whole chaplets by the insertion of grains of quartz connected by a string into the mantle of a species of Meleagrina; in other cases, a dozen enamelled figures of Buddha seated have been produced by inserting small plates of embossed metal in the valves of the same species.

The pearls are very small at first; they increase by annual layers deposited on the original nucleus, their brilliancy and shade of colour varying with that of the nacre from which they are produced. Sometimes they are diaphanous, silky, lustrous, and more or less iridescent; occasionally they turn out dull, obscure, and even smoky.

The pearl oyster is met with in very different latitudes; they are found in the Persian Gulf, on the Arabian coast, and in Japan, in the American seas, and on the shores of California, and in the islands of the South Sea; but the most important fisheries are found in the Bay of Bengal, Ceylon, and other parts of the Indian Ocean. The Ceylon fisheries are under Government inspection, and each year, before the fisheries commence, an official inspection of the coast takes place. Sometimes the fishing is undertaken on account of the State, at other times it is let to parties of speculators. In 1804 the pearl fishery was granted to a capitalist for £120,000; but, to avoid impoverishing all the beds at once, the same part of the gulf is not fished every year.

The great fishery for mother-of-pearl Pintadines (*Meleagrina margaritifera*) takes place in the Gulf of Manaar, a large bay to the north-east of the island: it commences in the month of February or March, and continues thirty days, taken collectively, and occupies 250 boats, which come from different parts of the coast; they reach the ground at daybreak, the time being indicated by a signal gun. Each boat's crew consists of twenty hands, and a negro. The rowers are ten in number. The divers divide themselves into two groups of five men each, who labour and rest alternately; they descend from forty to fifty feet, seventy being the very utmost they can accomplish, and eighty seconds the longest period the best divers can remain under

water, the ordinary period being only thirty seconds. In order to accelerate their descent, a large stone is attached to a rope. According to travellers the oars are used to rig out a stage, across which planks are laid over both sides of the boat; to this stage the diving-stone is suspended. This stone is in the form of a pyramid, weighing about fifty-six pounds; the cord which sustains it sometimes carries in its lower part a sort of stirrup to receive the foot of the diver. At the moment of his descent he places his right foot in this stirrup, or, where there is no such provision, he rests it on the stone with the cord between his toes. In his left foot he holds the net which is to receive the bivalves; then, seizing with his right hand a signal-cord conveniently arranged for this purpose, and pressing his nostrils with the left hand, he dives, holding himself vertically, and balancing himself over his foot.

Each diver is naked, except for a band of calico which surrounds his loins. Having reached the bottom, he withdraws his foot from the stone, which ascends immediately to the stage. The diver throws himself on his face, and begins to gather all the pintadines within his reach, placing them in his net. When he wishes to ascend he pulls the signal cord, and is drawn up with all possible expedition.

A good diver seldom remains more than thirty seconds under water at one time; but he repeats the operation three or four, and, in favourable circumstances, even fifteen or twenty times. The labour is extremely severe. On returning to the boat they sometimes discharge water tinged with blood by the mouth, nose, and ears. They are also exposed to great danger from sharks, which lie in wait for and frequently devour the unhappy divers.

They continue to fish till mid-day, when a second gun gives the signal to cease. The proprietors wait on shore for their boats, in order to superintend their discharge, which must take place before night sets in, in order to prevent concealment and robbery.

In past times the Ceylon fisheries were very valuable. In 1797 they are said to have produced £144,000, and in 1798 as much as £192,000. In 1802 the fisheries were farmed for £120,000; but for many years the banks have been less productive, and are now said to yield only the sum of £20,000 per annum.

The natives of the Bay of Bengal, those of the Chinese coast, of Japan, and the Indian Archipelago, all devote themselves to the pearl fishery, the produce being estimated to realise at least £800,000. Fisheries analogous to those of Ceylon take place on the Persian coast, on the Arabian Gulf, along the coast of Muscat, and in the Red Sea.

In these latter countries the pearl fishing does not commence till the months of July and August, the sea being at that time calmer than in other months of the year. Arrived on their fishing-ground, the fishermen range their barques at a proper distance from each other, and cast anchor in water from eight to nine fathoms deep. The process is pursued here in a very simple manner. When about to descend the divers pass a cord, the extremity of which communicates with a bell placed in the barque, under the armpits; they put cotton in their ears, and press the nostrils together with a piece of wood or horn; they close their mouths hermetically, attach a heavy stone to their feet, and at once sink to the bottom of the sea, where they gather indiscriminately all shells within their reach, which they throw into a bag suspended round their haunches. When they require to breathe they sound the bell, and immediately they are assisted in their ascent.

On the oyster-banks off the Isle of Bahrein the pearl fishery produces about £240,000; and if we add to this the addition furnished by the other fisheries of the neighbourhood, the sum total yielded by the Arabian coast would probably not fall short of £350,000.

In South America similar fisheries exist. Before the Mexican conquest the pearl fisheries were located between Acapulco and the Gulf of Tehuantepec; subsequently they were established round the Islands of Cubagua, Margarita, and Panama. The results became so full of promise that populous cities were not slow to raise themselves round these several places.

Under the reign of Charles V., America sent to Spain pearls valued at £160,000; in the present day they are estimated to be worth £60,000. In the places mentioned, the divers descend into the sea quite naked; they remain there from twenty-five to thirty seconds, during which space they can only secure three or four pintadines. They dive in this way a dozen times in succession, which gives an average of between thirty and forty bivalves to each diver.

The shells are carried on shore, and piled up on mats of Espartero grass. The mollusc dies, and soon becomes decomposed; it requires ten days to be thoroughly disorganised. When in a thoroughly decayed state, they are thrown into reservoirs of sea water, when they are opened, washed, and handed over to the dealers. The valves furnish *nacre*, and the *pearls* are found in the soft decayed substance of the mollusc.

The valves are cleansed, and piled up in tuns or casks; by taking

off their external surface plates of nacre are obtained more or less thick, according to the age of the mollusc.

Nacres of three kinds are distinguishable in commerce: silver lipped, bastard white, and bastard black. The first are sold in cases of 250 to 280 pounds; they are brought from the Indies, from China, and Peru. The ships of various nations import these shells as ballast. The second is delivered in casks of 250 pounds weight; it is a yellowish white, and sometimes greenish; sometimes red, blue, and green.

Pearls form by far the most important product of the animal. When they are adherent to the valves they are detached with pincers; but, as a rule, they are found in the soft tissues of the animal. In this case the substance is boiled, and afterwards sifted, in order to obtain the most minute of the pearls; for those of considerable size are sometimes overlooked in the first operation. Months after the mollusc is putrefied miserable Indians may be observed busying themselves with the corrupt mass, in search of small pearls which may have been overlooked by the workmen.

The pearls adherent to the valve are more or less irregular in their shape; they are sold by weight. Those found in the body of the animal, and isolated, are called *virgin pearls*, or *paragons*. They are globular, ovoid, or pyriform, and are sold by the individual pearl. In cleaning them, they are gathered together in a heap in a bag, and worked with powdered nacre, in order to render them perfectly pure in colour and round in shape, and give them a polish; finally, they are passed through a series of copper sieves, in order to size them. These sieves, to the number of twelve, are made so as to be inserted one within the other, each being pierced with holes, which determine the size of the pearl, and the commercial number which is to distinguish it. Thus, the sieve No. 20 is pierced with twenty holes, No. 50 with fifty holes, and so on up to No. 1,000, which is pierced with that number of holes. The pearls which are retained in Nos. 20 to 80, said to be *mill*, are pearls of the first order. Those which pass and are retained between Nos. 100 to 800 are *vivadoe*, or pearls of the second order; and those which pass through all the others and are retained in No. 1,000 belong to the class *tool*, or seed pearls, and are of the third order.

They are afterwards threaded; the small and medium-sized pearls on white or blue silk, arranged in rows, and tied with ribbon into a top-knot of blue or red silk, in which condition they are exposed for sale in rows, assorted according to their colours and quality. The small or seed pearls are sold by measure or weight.

In America the bivalve is opened with a knife, like the common edible oyster, and the pearl is obtained by breaking up the mollusc between the finger and thumb, without waiting for its decomposition; nor is it boiled. This is a much longer and less certain process than that pursued in the East; but the pearls are preserved in greater freshness by the process—for the nacre of the dead shells is less brilliant than that of those which have been suddenly killed and at once separated from the soft parts.

Some few pearls have become historical for their size and beauty. A pearl from Panama, in the form of a pear, and about the size of a pigeon's egg, was presented in 1579 to Philip II., King of Spain, it was valued at £4,000. A lady of Madrid possessed an American pearl in 1605 valued at 31,000 ducats.

Pope Leo X. purchased a pearl of a Venetian jeweller for £14,000. Another was presented to the Sultan Soliman the Great by the Venetian Republic valued at £16,000. Julius Cæsar, who was a great admirer of pearls, presented one to Servilia which was valued at a million of sesterces, about £48,000 of our money.

There is no data for the volume or value of the two famous pearls of Cleopatra: one of these, which the queen is said to have capriciously dissolved in vinegar and drank—Heavens preserve us from such a draught!—is said by some authors to have been worth £60,000; the other was divided into two parts, and suspended one half from each ear of the Capitoline Venus. Another pearl was purchased at Califa by the traveller Tavernier, and is said to have been sold by him to the Shah of Persia for the enormous price of £180,000.

A prince of Muscat possessed a pearl so valuable—not on account of its size, for it was only twelve carats, but because it was so clear and transparent that daylight was seen through it—that he refused £4,000 for it.

In the Zozema Museum at Moscow there is a pearl, called the "Pilgrim," which is quite diaphanous; it is globular in form, and weighs nearly twenty-four carats. It is said that the pearl in the crown of Rudolph II. weighed thirty carats, and was as large as a pear. This size, besides being indefinite, is more than doubtful.

The Shahs of Persia actually possess a string of pearls, each individual of which is nearly the size of a hazel nut: the value of this string of jewels is inestimable.

At the Paris Exposition of 1855, her Majesty the Queen exhibited some magnificent pearls; and on the same occasion the Emperor of the French exhibited a collection of 408 pearls, each weighing over

nine pennyweights, all of perfect form and of the finest water. The Romans were passionately fond of pearls, and they have transmitted their taste to the Eastern nations, who attach notions of great grandeur and wealth to the possessor of large and brilliant pearls.

The genus *Pinna* was so called by Linnæus, from one of the species which was so designated from the resemblance of its byssus to the aigrette or plumelet which the Roman soldiers attached to the helmet. French naturalists name them *jambonneaux*, from their singular resem-

Fig. 165.—Pinna rudis (Linnæus).

Fig. 166.—Pinna nigrina (Lamarck).

blance to a dried ham (Figs. 165 and 166), their brown, smoky colour not a little aiding the resemblance. The shell is fibrous, horny, very thin and fragile, compressed, regular, and equivalve, triangularly pointed in front, round or truncated behind. The hinge is linear, straight, and without teeth; the ligament, in great part internal, occupies more than half the anterior portion of the dorsal edge of the shell, forming a straight elongated fossette.

The animal is thick, elongated, with mantle open behind, presenting a conical furrowed foot, bearing a considerable byssus.

The species of the genus *Pinna* are found in almost every sea, and at various depths; they are constantly attached by their byssus, and

in a vertical position, the larger side of their shell being uppermost. They are found on sandy bottoms in considerable numbers. The byssus has in all ages fixed the attention of the Mediterranean fishermen upon these curious shells. With its tuft of fine silky hairs, six or seven inches in length, of a fine reddish-brown hue, articles of luxury are formed, which are often mentioned by the Latin writers. The threads of the byssus, which are remarkable for their unalterable colour, were formed by both Greeks and Romans into a fabric to

Fig. 167.—Pinna nobilis, with its byssus (Linnæus).

Fig. 168.—Pinna bullata (Swainson).

which there is nothing analogous in the world. The Maltese and Neapolitans still fashion soft tissues from it, but the stuffs so manufactured are mere objects of curiosity.

Some thirty species are described as living in the several seas. *Pinna nobilis* (Fig. 167), the byssus of which was employed in the ancient Neapolitan industry, inhabits the shores of the Mediterranean. *Pinna bullata*, Swainson (Fig. 168), is also a well-known species.

Our twenty-first family, Ostreidæ, contains the genera Lima, Spondylus, Pecton, Anomia, and the all-important genus *Ostrea*.

The common oyster, *Ostrea edulis*, is found in many seas. It is unequally valved, modified in shape by the form of the submarine body to which it happens to be attached. The lower or adherent valve is concave, always the largest; the upper one is thin, usually flat; the shell is lamellar, rough externally, and seems to be composed of broken layers, adhering slightly to each other, as if the successive layers had been built up from within, and each succeeding one was an enlargement upon its predecessor. The hinge which unites the valves is an elastic toothless ligament, placed behind the centre, which opens the valves.

The interior surface of the valves is smooth and white, diaphanous or pearly towards the centre, but near the back an oval or rounded impression may be observed, to which a thick and whitish fleshy muscle is attached. This is the central muscle which draws the valves together, hermetically closing them upon the animal. This muscle is cut through in the process of opening the oyster.

The animal has no power of locomotion; its foot is very small, and often wanting, no siphon, but lies with its mouth open, and firmly attached to its shell. The shell itself is always adherent, as if soldered to the rock or other submarine body, the point of adherence being near the summit of the lower valve.

Let us suppose the oyster opened by the cutting through of the ligament of the central muscle and of the adductor muscles. When displayed before our eyes, we see in the bottom of the shell a flattened shapeless animal, semi-transparent, greyish, and somewhat oval-shaped. The gastronomist, who seldom sees beyond his nose, thinks that, in spite of its culinary merits, the oyster belongs to the lowest rank of animal existence; but he deceives himself, and does not know how complex and delicate is the organisation of the humble bivalve. The animal is enveloped in a sort of smooth, thin, contractile tissue called the *mantle*, which folds round it, presenting two lobes, separated on the greatest part of its circumference, and forming a sort of hood, the summit of which abuts upon the hinge of the bivalve. The edges of this mantle are fringed with very small cilia, which the creature can extend and draw back at pleasure, and which seem to be gifted with a certain amount of sensibility. It is this mantle which secretes and deposits the calcareous matter which forms the shell, each plate of which is an enlargement on the preceding one, until it constitutes a pyramid of thin convex lamellæ.

At the point where the lobes of the mantle meet, near the summit of the valve, is the mouth of the animal, with its thin membranous lips. This organ is large and dilatable, and is accompanied by four

flat triangular lips, by means of which the animal introduces its food into the stomachal cavity.

A very short gullet is attached to the mouth, which leads to a pear-shaped stomach. After this stomach comes a slender sinuous intestine, which, leading obliquely towards the interior, descends a little, then re-ascends, passes behind the stomachal cavity, nearly on a level with the mouth, crossing its first path in order to reach the posterior face of the adductor muscle, in the centre of which it terminates with a free opening. The stomach and intestines are surrounded on all sides by the liver, which alone constitutes a notable portion of the total mass of the organs. This liver is of a blackish colour, pervaded with a deep yellow liquid, which is the bile. Thus, the stomach and intestines of the oyster are surrounded by the liver; the mouth is connected with the stomach, and the intestinal canal has an opening of its own.

The heart of the oyster is placed under the liver, and is surrounded closely by the terminal part of the intestines. It is composed, like the same organ in the superior animals, of two distinct cavities, an auricle and ventricle. From the ventricle issues a vessel, which is divided into three distinct canals. One of these carries the blood towards the mouth and labial tentacles; another carries it towards the liver; the last distributes the nourishing fluid to the rest of the body. The blood of the oyster is limpid and colourless; it passes successively from the auricle of the heart, where it is vivified, into the ventricle, and from this last cavity into the great vessel of which we spoke, which distributes it throughout the interior of the animal.

The oyster thus possesses a true circulation; not that double system which characterises the mammals, and which includes arterial and pulmonary action, but a simple circulation, as it exists in fishes and many other animals. It breathes also under the water, after the manner of fishes, being, like the fish, provided with organs called gills or *branchiæ*, whose function is to separate the oxygen dissolved in the water from its other ingredients; these branchiæ, which are placed between the mantle folds, consist of a double series of very delicate canals, placed close together, not unlike the teeth of a fine comb.

Having no head, the oyster can have no brain; the nerves originate near the mouth, where a great ganglion is visible, whence issues a pair of nerves which distribute themselves in the regions of the stomach and liver, terminating in a second ganglion, situated behind the liver. The first nervous branch distributes its sensibility

to the mouth and tentacles; the second, to the respiratory branchiæ. With organs of the senses oysters are unprovided. Condemned to a sedentary life, riveted to a rock where they have been rooted, as it were, in their infancy, they neither see nor hear; touch appears to be their only sense, and that is placed in the labial tentacles of the mouth.

The mode of reproduction in these creatures is very peculiar. The oyster unites in itself the functions of both sexes. In the same organ are found the eggs—called *spat*—and the mobile corpuscles intended to fertilise them.

The eggs are yellowish in colour, and exist in prodigious numbers in each individual. We are assured that an oyster may carry as many as two millions of eggs! Nature always makes ample provision for the preservation of species; but in spite of the most ample provision here displayed, man, in his reckless and wasteful gluttony, has all but defeated Nature. A tyro can compute how many individuals a bank of oysters reckoned at 20,000 would produce, at the rate of 2,000,000—or 800,000, as other authorities assert—from each one annually, and it will amount to an incredible number—in fact, each would multiply itself by millions in three years; and yet, thanks to our improvident management, oysters get scarcer every year.

The spawning season is usually from the month of June to the end of September: during this season the oysters deposit their eggs in the folds of their mantle. During the period of incubation the eggs remain surrounded by mucous matter, which is necessary to their development, the whole having the appearance of a thick cream —this milky appearance being due to the accumulated mass of ova surrounded by the mucus: this mass undergoes various changes of colour while losing its fluidity, becoming successively yellowish, greyish, brown, and violet, a condition which indicates the near termination of the embryo state, for the oysters do not, like many other inhabitants of the sea, eject their ova; they incubate them in the folds of their mantle, and only discharge them when they can live without maternal protection. Nothing is more curious to witness than a bank of oysters at the spawning season. Every adult individual of which it is composed throws out its phalanx of progeny. A living dust is seen to exhale from the oyster bank, troubling the water and giving it a thick cloudy appearance, which disseminates itself little by little in the liquid, until it dissipates and loses itself far from its focus of production. The *spat* is soon scattered far and wide by the waves; and unless the young oyster finds some solid body to which it can attach itself, it falls an inevitable victim to the larger

animals which prey upon it. In this its infant state, when it has just left the protection of the parent shell, the microscope reveals the young bivalve as having a perfect shell, and having an apparatus which is also for the time a swimming *pad*, ready to adhere to the first solid body which the current drives it against. This pad or cushion (which is represented in Fig. 169) is furnished with vibratile cilia, disposed round the young shell. Aided by the powerful adductor muscles, with which it is also provided, this cushion is projected through the water at the will of the young inhabitant, which has every facility for the purpose: it is even said to swim about near the mother, before final dismissal from the maternal protection, seeking shelter at the least alarm between the valves of the parent shell. The

Fig. 169.—Young Oysters furnished with locomotive organs.

pad disappears after the young oyster has finally attached itself to a permanent bed of its own.

Before this period of its life arrives, however, many are the dangers to which it is exposed: its enemies are numerous; they lie in ambush for it in every cranny! It has to guard itself against eddies and currents, which would drive it out to sea, and mud banks, in which it would be smothered. Crustaceans, worms, and cœlenterates, with other equally voracious marine inhabitants, prey upon it. Last, but not least, come the terrible and multiplied engines of the eager fisherman—and we can readily comprehend why it is that the oyster should be provided with such accumulated masses of ova.

If the young bivalve is fortunate enough to escape all the snares and dangers we have enumerated, it grows rapidly. It is quite microscopic at the period of its discharge from the parent shell; at one month it is of the size of a large pea, at the end of six months it is about three-quarters of an inch, a year after its birth an inch and a half to two inches, and finally, at the end of three years it has become

Fig. 170.—Groups of Oysters of different ages attached to a block of wood.

merchandise; that is to say, it is in a state to be sent to the parks for preservation and feeding. In Fig. 171 we see a group of oysters,*

* We give this illustration as representing the comparative size of the oysters at different ages; but it is necessary to state that the specimens were artificially

of various ages, attached to a piece of wood: A being oysters of twelve to fifteen months, B five or six months, C three to four months, D one to two months, and E oysters twenty days after birth.

The species of oysters usually eaten are the common oyster (*Ostrea edulis*, Linn.) of our own coasts and the opposite shore, and the horsefoot oyster (*O. hippopus*, Linn.) On the Mediterranean coast are the rose-coloured oyster (*O. rosacea*, Favanue), and the milky oyster (*O. lacteola*, Moquin-Tandon), besides the small and little-known crested oyster (*O. cristata*, Born), and the folded oyster (*O. plicata*, Chemnitz). On the Corsican coast is the oyster called foliate (*O. lamellosa*, Brocchi).

There are two principal varieties of the common oyster dredged on the French coast, which differ in size and delicacy of flavour. These are the Cancale and Ostend oyster. When the first has been fed for some time in the oyster park, and has assumed its greenish hue, it is designated the Marenna oyster, from "the park" so named in the Bay of Seudre. Of this green colour we shall speak elsewhere.

Who believed Uncle Jack when he told us in our youth of oysters growing on trees, and oysters so large that they required to be carved like a round of beef—of oysters on the Coromandel coast as large as soup-plates? Nevertheless Uncle Jack's stories were true: there are oysters which require carving, and oysters have been plucked off trees. In some parts of America they grow very large. Virginia possesses nearly 2,000,000 acres of oyster-beds. The seaboard of Georgia is famed for its immense supplies; the whole coast of Long Island, extending to 115 miles, is occupied with them, and all over the States evidence is to be seen of the estimate in which the favoured bivalve is held by the American people.

Natural oyster-beds are found in bays, estuaries, and other sheltered sinuosities of the coast, with shelving and not too rocky bottoms, such places being, according to the natural law of production, favourable for the increase of the colony. Such banks abound in every sea. In France the oyster-beds of Rochelle, of Rochefort, the Isles of Ré and Oleron, the Bay of St. Brieuc, of Cancale, and Granville, are famous for the quality of their produce.

On the Danish coast there are from forty to fifty oyster-banks, situated on the west coast of Schleswig; the best bed lying between the small isles of Sylt, Amron, Fohr, Pelworm, and Nordstrand. At

attached to the block by means of glue for exhibition. Oysters always attach themselves by the back of the rounded shell near to the hinge, as stated at p. 373.

he point of Jutland, and opposite Shagen, beds less productive are ound.

The great oyster-beds of England extend from Gravesend, in the stuary of the Thames and Medway, along the Kentish coast on the ne hand, and the estuary of the Colne and other rivers on the Essex coast. The Frith of Forth is also famous for its oyster-beds, xtending from Prestonpans far up the estuary of the river; but, uriously enough, all these great banks, without exception, have been mpoverished, and all but exhausted, by improvident dredging, in pite of the "close season" which has always existed.*

"He was a bold man who first ate an oyster," has been said efore. The name of the courageous individual has not been ecorded, but Mr. Bertram, in his "Harvest of the Sea," tells us a egend concerning him:—"Once upon a time"—it must have been a ong time ago—"a man of melancholy mood was walking by the hores of a picturesque estuary, listening to the monotonous murmur of the sad sea-waves, when he espied a very old and ugly oyster-shell all coated over with parasites and sea-weeds. It was so unpre-possessing that he kicked it with his foot, and the animal, astonished at receiving such rude treatment on its own domain, gaped wide with indignation, preparatory to closing its valves still more tightly. Seeing the beautiful cream-coloured layers that shone within the shelly covering, and fancying that the interior of the shell itself must be beautiful, he lifted up the aged 'native' for further examination, inserting his finger and thumb within the valves. The irate mollusc, thinking, no doubt, that this was meant as a further insult, snapped its pearly doors down upon his fingers, causing him considerable pain. After releasing his wounded digits, our inquisitive gentleman very naturally put it in his mouth. 'Delightful!" exclaimed he, opening wide his eyes; 'what is this?' and again he sucked his finger. Then the great truth flashed upon him that he had found out a new delight—had, in fact, achieved the most important dis covery ever made. He proceeded at once to realise the thought. With a stone he opened the oyster's stronghold, and gingerly tried a piece of the mollusc itself. 'Delicious!' he exclaimed; and there and then, with no other condiment than its own juice, with no accompaniment of foaming brown stout or pale Chablis to wash it

* The cause of the present scarcity of oysters is a much-vexed question. Mr. Frank Buckland, a most excellent authority on oyster and fish culture attributes it to sudden changes of temperature at the critical period when th spat is newly formed, rather than to over-dredging.

down, no newly-cut, well-buttered brown bread, did that solitary anonymous man inaugurate the first oyster banquet."

Another story makes the act of eating the first oyster a punishment. The poetaster also had his views on the subject:—

> "The man had sure a palate covered o'er
> With brass, or steel, that on the rocky shore
> First broke the oozy oyster's pearly coat,
> And risked the living morsel down his throat."

And ever since men have gone on eating oysters. Emperors and poets, princes and priests, pontiffs and statesmen, orators and painters, have feasted on the favoured bivalve.

Man has made use of the oyster from the most remote antiquity. Among the *débris* of festivals which precede by ages the epoch of written history, oyster-shells are found. On the "midden heaps" of northern Europe they are often discovered, mingling with other rubbish and with stone implements, evidently the refuse of very ancient feasts. We have all read of the classic feasts of the Romans, which began with oysters brought from fabulous distances. Vitellius ate oysters all day long, and the idea prevailed that he could eat a thousand. Calisthenes, the philosopher, was a passionate oyster eater; so was Caligula; Seneca the wise could eat his hundred; and the great Cicero did not despise the savoury bivalve. Lucullus had sea-water brought to his villa from the shores of Campania, in which he bred them in great abundance for the use of his guests. To another Roman, Sergius Orata, we owe the original idea of the oyster-park. He invented the oyster-pond, in which he bred oysters, not for his own table, but for profit.

Among modern celebrities whose love of oysters is recorded, we may mention Louis XI., who feasted the learned doctors of the Sorbonne once a year on oysters. Another Louis invested his cook with an order of nobility, in reward for his skill in cooking them. Cervantes loved oysters, although he satirised oyster-dealers. Marshal Turgot used to eat a hundred or two just to whet his appetite. Rousseau, Helvetius, Diderot, the Abbé Raynal, and Voltaire, are recorded lovers of oysters. Danton, Robespierre, and other of the revolutionists, frequented the oyster *salons* of Paris. Cambaceres was famous for his oyster feasts; and it is recorded of the great Napoleon that he always partook of the bivalve on the eve of his great battles, when they could be procured.

In short, it has been demonstrated as a gastronomic truth that there is no feast worthy of a connoisseur where oysters do not come to the front. It is their office to open the way by that gentle excite-

ment which prepares the stomach for its proper function, digestion; in a word, the oyster is the key of that paradise called appetite. "There is no alimentary substance, not even excepting bread, which does not produce indigestion under given circumstances," says Reveille-Parise, "but oysters never." This is an homage which is due to them: "We may eat them to-day, to-morrow, eat them always, and in profusion, without fear of indigestion." Dr. Gastaldi could swallow, we are assured, his forty dozen with impunity—quite a bank must he have eaten! He was unfortunately struck with apoplexy at table before a *pâté de foie gras.*

Montaigne quaintly says, to be subject to colic, or deny oneself oysters, presents two evils to choose from, since one must choose between the two, and hazard something for his pleasure.

England has always been famous for its oysters, and its pearls are said to have been the chief incentive to Cæsar's invasion. It is not, therefore, to be supposed that British magnates could be indifferent to the "native." But the bivalve has perhaps been more celebrated, in prose and verse, north of the Tweed than south, where silent enjoyment is more relished than noisy demonstration. Dugald Stewart, Hume, Cullen, and other Scotch philosophers of the last centuries, had their "oyster ploys" as an accompaniment to their "high jinks," in the quaint and dingy taverns of the old town of Edinburgh; and what the bivalve has been to modern celebrities let the "Noctes Ambrosianæ" tell.

The oyster may thus be said to be the palm and glory of the table. It is considered the very perfection of digestive aliment. From Stockholm to Naples, from London to St. Petersburg, it is always in request. At St. Petersburg they cost a paper rouble (nearly one shilling), and at Stockholm fivepence each. For the last year or two the English oyster eater has had to pay from two shillings to half-a-crown a dozen for choice natives.

For his daily nourishment a man of middle size requires a quantity of food equal to twelve ounces of dry nitrogenised substance. According to this calculation, it would be necessary to swallow sixteen dozen of oysters to make up the necessary quantity. The small proportion of nutritive matter explains the extreme digestibility of the oyster. It also explains the immense consumption of them attributed to the Emperor Vitellius. Without this being so Vitellius, all emperor and master of the world as he was, never could have absorbed twelve hundred oysters by way of whetting his appetite.

The gourmets were long of opinion that the quadrangular-shaped muscle or cushion in the oyster was the most savoury and exciting

part. Certain distinguished amateur performers adopted and proclaimed the principle of dividing transversely the body of the mollusc, and eating the cushion only. Natural history explains this gastronomical discovery. It recognises the fact that the bile secreted by the liver is contained in this substance, that it accelerates while it exhausts the qualitative surface of the tongue and palate, aiding also the functions of the stomach.

We have described the organisation of the oyster, and we have said something of the enjoyment it confers. Did it ever occur to the various societies for the prevention of cruelty to animals to consider whether the oyster might not be a very proper object of their care? Let us see if we can make out a case for them.

We commence operations upon them by dragging them violently from their own element. We place them out afterwards in water-parks, more or less briny and unsuitable, filled with villanous green matter, which presently pervades their breathing apparatus, impregnating, obstructing, and colouring it; the oyster swells, fattens, and soon attains that state of obesity which verges on sickness.

When the poor creature has attained its livid green colour, it is fished up a second time. Alas! it is now doomed neither to return to the sea, to the park, nor to its native rock. It has water at its disposal only in the very small quantity which it can retain between its two valves, a quantity scarcely sufficient to keep away asphyxia. It is shut up in an obscure narrow basket—an ignoble prison-house, without door or window. It seems to be forgotten that they are animals: they are piled upon the pavement like inert merchandise. The basket is carried by railway; the animal, shaken out of existence almost, is at last landed at the door of some oyster-shop; and this is the critical moment for the poor bivalve! It is scarcely thrown into a tub with water enough to remind it of its former luxurious life, when it is again seized by the pitiless master of its fate. With a great knife he brutally opens the shell, cuts through the muscle by which it adheres to the valve, and violently detaches it, after breaking the hinges. It is now laid out on a plate, exposed to every current of air, and in this state of suffering it is carried to the table. There the pitiless gourmet powders it over with the most pungent pepper, squeezes over the wounded and still bleeding body the abomination of its race in the shape of citric acid or vinegar, and then, alas! with a silver knife which cannot cut, he wounds and bruises it a second time; or, worse still, he saws and tears and rends it from its remaining shell; he seizes it with a three-pronged fork, which is driven through

liver and stomach, and throws it into his mouth, where the teeth cut, crush, and grind it, and, while still living and palpitating, reduced to an inanimate mass, these organs fast triturate it, while our gourmet is drinking its blood, its fat, and its bile.

We have said that oysters have no head, no arms—that they are without eyes (although that is disputed), without ears, and without nose; that they do not stir—that they never cry!

Agreed, perfectly agreed; but all these negatives do not prevent its being sensible to pain. Two eminent Germans, Herren Brandt and Ratzeburg, have proved that they possess a well-developed nervous system; and if they possess sensation they must suffer. "Can an animal with nerves be impassible?" asks Voltaire. "Can we suppose any such impossible contradiction in Nature?"

There is consolation, however, for all concerned. Let the humanitarian fishermen, oyster-dredgers, merchants, and consumers, console themselves with the vast difference between the helpless imperfect mollusc and the higher classes of animals. In the case of the former we swallow the animal, scarcely thinking of its animal nature. It is the denizen of another element, lives in a medium in which we cannot exist, presents itself in a form, so to speak, degraded—an obscure vitality, motions undecided, and habits scarcely discernible. We may therefore see the oyster mutilated, mutilate them himself, grind them, and swallow them, without emotion or remorse.

A learned naturalist dwelling on the sea-shore possessed himself one day of a dozen oysters. He wished to study their organisation; he turned them, and turned them again, examined their several parts inside and out. He made drawings of and described them, and, having satisfied himself that he had exhausted his scientific skill in observing them, he swallowed them; the interesting bivalves had lost nothing of their excellence, and the examination did not prejudice their flavour.

Oyster fishing is pursued in a very different manner in different countries. Round Minorca, divers, with hammers attached to the right hand, descend to the depth of a dozen fathoms, and bring up in their left hand as many of the bivalves as they can carry, two fishermen, usually associating for the purpose, diving alternately until the boat is filled. On the English and French coasts the dredge is employed, as represented in PLATE XVI. This operation is also necessary to keep down the marine vegetation, which would stifle the oysters; the engine is of iron, and is very heavy. It is thrown overboard, and descends to the bottom of the sea, which it ploughs and

scrapes up, detaching the oysters, and throwing them into a net attached to the dredge. In this process oysters, large and small, are torn from their native bed, some going into the net, but a larger number are buried in the mud. It would be difficult to imagine a more destructive process; and when the habits of the oyster are considered, it is evidently one admirably contrived to destroy the race.

In France oyster dredging is conducted by fleets of thirty or forty boats, each carrying four or five men. At a fixed hour, and under the surveillance of a coast-guard in a pinnace bearing the national flag, the flotilla commences the fishing. In the estuary of the Thames the practice is much the same, although no official surveillance is observed. Each bark is provided with four or five dredges, each resembling in shape a common clasp purse. These dredges are formed of network, with a strong iron frame, as represented in Fig. 171, the iron frame serving the double purpose of acting as a scraper, and keeping the mouth open, while giving it a proper pressure as it travels over the oyster-beds. When the boat is over the oyster scarp, the dredge is let down, and no more attractive sight exists than that presented by the well-appointed Whitstable boats on one side of the estuary, or the Colne boats on the other, as they wear and tack over the oyster-beds, bearing up from time to time to haul in the dredge, and empty its contents into the hold. The tension of the rope is the signal for hauling in, and very heterogeneous are the contents of the dredge—sea-weeds, star-fishes, lobsters, crabs, actinia, and stones. In this manner the common oyster-beds on both sides of the Channel were ploughed up by the oyster dredger pretty much as the ploughman on shore turns up a field. The consequence was that, twenty years ago, the French beds were totally exhausted, and France had to look to foreign countries for its oysters. Oyster-farms which had employed 1,400 men and 200 boats were reduced to employing 200 men and twenty boats. Similar results from over-dredging would have followed, no doubt, on this side the Channel had the mollusc not been protected by the companies and private proprietors who held the oyster-beds in the large estuaries. This state of things in France led to some important discoveries in the science of oyster culture, which have produced important changes there.

The name of Sergius Orata has already been mentioned as a cultivator of oysters. He lived in the fifth century before our era, and according to Pliny he first attempted parking oysters at Baia in the time of the orator Lucius Crassus. He was the first to recognise the

uperior flavour of the oysters of the Lucrin Lake, the Avernus of the oets, probably for trade reasons of his own, for then, as now, Reveille-Parise remarks, writing on the subject, "tradesmen speculated on the veaknesses of human gourmandism." But Sergius really created a ew industry, which is still practised in thousands of places much as e left it. As a proof of the perfection to which Sergius had brought yster culture, his contemporaries said of him, in allusion to the anging banks which he invented, that if he had been prevented from

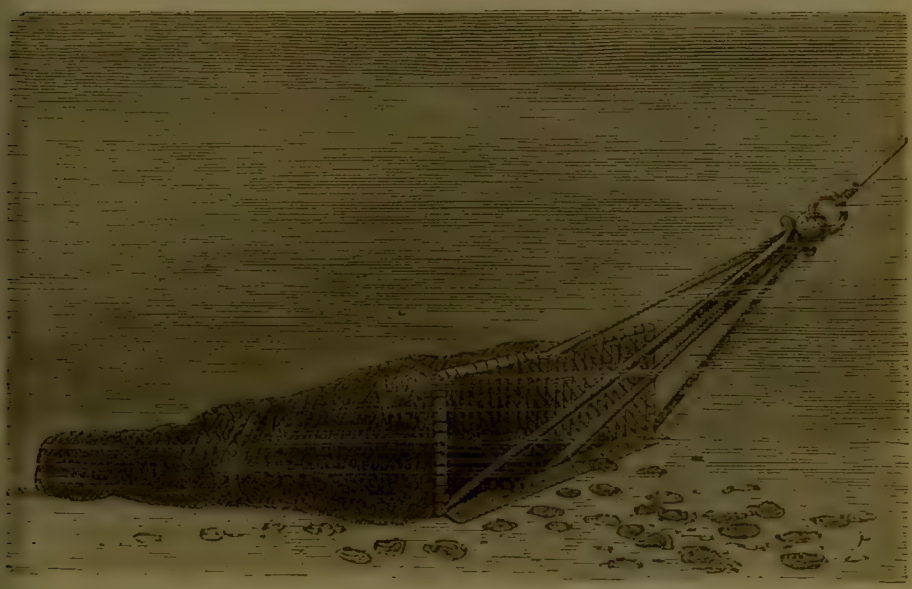


Fig. 171.—Dredge employed in Oyster fisheries.

aising oysters in the Lucrin Lake, "he would have made them grow on the house-tops." The traveller who visits this celebrated lake inds now only a miry puddle. The precious oysters placed there by Catiline's grandfather are replaced by a host of miserable eels, which eap in the mud; vile mountains of ashes, coal, and pumice-stone, which were thrown up in one night like a mushroom, having reduced the once celebrated lake into the state described.

Rondeletius also speaks of a fisherman who understood the art of oyster culture.

The Neapolitan Lake Fusaro—the terrible Acheron of the poets—is a great oyster-park, in which Art is made effectually to aid Nature in the multiplication of its products. This famous oyster-bank, which

is represented in PLATE XVII., lies in the neighbourhood of Baia and Cumæ. It forms one of the most interesting spots in that beautiful bay. In the month of February, 1865, M. Figuier tells us he traversed its celebrated coast, seated himself on the banks of the historical lake, and tasted the produce of this curious manufacture of living beings, whose origin dates from the Roman period.

Lake Fusaro was in ancient times a place of evil report: Virgil immortalised it as the mythological Acheron; but its landscape had

Fig. 172.—Artificial Oyster-bank in Lake Fusaro.

nothing of the sadness and desolation which accords with the sojourn of the dead. It is a salt pond, shaded with a girdle of magnificent trees. It is about a league in circumference, and about a fathom in depth at its deepest part; its bottom is muddy and black, like the rest of this volcanic region.

It will be understood, from what has been said, that the chief obstacle to the reproduction of oysters is the absence of any solid body to which the young spawn can attach itself, and the means of shelter from animals which prey upon them. The fishermen living on the shores of Lake Fusaro have long realised this, and provided against it by warehousing, as it were, in the lake near the sea, the oysters ready to discharge their spawn, while retaining the young generations

XVII.—General View of the Oyster Parks on Lake Fusaro.

captive in the protected basins, where they are sheltered from various causes of destruction to which oysters are exposed in the open sea.

Upon the bottom of the lake, and all around it, the proprietors of Fusaro have here and there constructed hillocks, with stones heaped up, and artificial rocks, raised sufficiently to shelter the depôts from mud and slime. Upon these rocks they deposit the young oysters gathered in the Gulf of Tarentum. Each of these rock-works is surrounded by a girdle of piles, driven close to each other, and raised a

Fig. 173.—Pillars with cords attached in Lake Fusaro.

little above the surface of the water, as represented in Fig. 172. Other piles are distributed in long lines, and bound to each other by a cord, from which are suspended fagots of young wood. In the spawning season the oysters which have been deposited on the artificial rocks discharge the myriads of young fry which have been nurtured in the folds of their mantles. The fagots suspended from the piles arrest the fry before they are driven away by the waves. By these precautions the proprietors of Fusaro have provided for the preservation of the young fry, besides removing many of the natural enemies of the young oyster.

In other places the piles are distributed in long lines and bound together by strong cords, from which fagots of brushwood are suspended, on which the young spawn lay hold, as in Fig. 173.

By means of these arrangements the pregnant oyster deposits its very numerous progeny in quiet repose; the young fry are intercepted by the fagots and hurdles suspended between the piles, where the young oysters develop themselves under the favourable conditions of repose, temperature, and light. When the fishing season arrives, the piles and fagots which surround the beds are removed, and the oysters are gathered suitable for market. The oysters thus selected for sale are packed loosely in osier baskets, and sunk, while waiting for purchasers, into a reserve or park. This park is established on the shores of the lake. It is constructed of piles, which support a gangway, provided with hooks, from which the baskets, filled with living oysters, are suspended, ready for sale.

Some twenty years ago the oyster-beds of France had become totally exhausted under the open system of dredging; and circumstances having brought the protective system pursued at Fusaro under the notice of M. Coste—a learned academician, to whom France is indebted for restoring to it its oysters—he reported to the Emperor in 1858 that at Rochelle, Marennes, Rochefort, at the Isles of Ré and Oleron, where there had been formerly twenty-three oyster-beds, there were now only five, and these in danger of being destroyed by the increase of mussels; that at the Bay of St. Brieuc, so naturally suited for oyster culture, the beds were reduced to three; that even on the classic oyster grounds of Cancale and Granville, it was only by the most careful administration that their destruction was prevented, while the increasing numbers of consumers threatened altogether to destroy an industry essentially necessary for the support of a maritime population.

The impulse given by this report has been productive of the most satisfactory results in France. All along the coast the maritime populations are now actively engaged in oyster culture. Oyster parks, in imitation of those at Fusaro, have sprung up. In his appeal to the Emperor, M. Coste suggested that the State, through the Administration of Marine, and by means of the vessels at its command, should take steps for sowing the whole French coast in such a manner as to re-establish the oyster-banks now in ruins, extend those which were prosperous, and create others anew wherever the nature of the bottom would permit. The first serious attempt to carry out the views of the distinguished academician was made in the Bay of St. Brieuc. In the month of April in the same year in which his report was received operations commenced by planting 3,000,000 mother-oysters which had been dredged in the common ground; brood from the oyster grounds at Cancale and

'réquiers were distributed in ten longitudinal lines on tiles, fragments of pottery, and valves of shells. At the end of eight months ne progress of the beds was tested, and the dredge in a few ninutes brought up 2,000 oysters fit for the table, while two scines drawn up at random contained nearly 20,000, from one to vo inches in diameter. Two of these fascines exposed to public iew at Béni and Patrieux excited the astonishment of the maritime opulation.

This result encouraged M. Coste to pursue his experiments upon greater scale; and he now proposed to bring the whole littoral under regulated system of oyster culture. In the roads of Toulon and in ake Thau, which touches this port, the same system was put in force y the Administration of Marine as had already been done in the Bay f Arcachon and in the Isle of Ré. In these localities oyster culture ssumed gigantic proportions. Associations were formed for the urpose of prosecuting them, and forming oyster-parks.

These exertions roused the curiosity of foreign nations. Van eneden, the distinguished Professor of Natural History at Louvain, nd M. Eschrecht of Copenhagen, visited France, to study the rangements for oyster culture. M. Coste demonstrated that parks ould be established on all places visited by the tide; and, under his lvice, the Bay of Arcachon is now transformed into a vast field of roduction, which increases every day, giving the happiest presages f an abundant harvest. Already 1,200 capitalists, associated ith a similar number of fishermen, have caused a surface of 988 cres, which is exposed at low water, to be planted with oysters. In is bay the State has organised two model farms for experimental urposes, in which tiles, fascines, and valves of shells are laid down, ith other appliances, to which the young oysters may attach themlves. These expedients have been so successful, that the park, hich has cost about £114, is now estimated to be worth about £8,000 in money, with a total of 5,000,000 oysters, large and small. he Isle of Ré, which was originally surrounded by a muddy bottom l adapted for oyster culture, has been totally changed, so that in two ears four leagues of foreshore have been turned into a rich and rofitable oyster-bed; 1,200 parks are in full activity, and 2,000 thers are in course of construction, the whole forming a complete ırdle round the island.

Every one has heard of the green oysters of Marennes, the reservation, amelioration, and ripening of these oysters, so to speak, epresenting a very considerable branch of industry in France. In rder to give the reader some idea of its importance, we shall give

here a brief summary of M. Coste's voyage of exploration on the French littoral.

The parks at Marennes, in which the oysters are placed in order to acquire the green colour which characterises them, are basins stretching along both banks of the Seudre for many leagues. They are locally known as *claires*, and differ from the oyster-parks of other countries in this particular—that, while the ordinary parks are so arranged as to be submerged at every return of the tide, the basins of Marennes are so arranged that they can only be submerged at spring tides; that is, at the new and full moon, when the waters rise beyond the ordinary level.

The basins or *claires* occupy from 250 to 300 square yards of superficies; two sluices permit of the entrance and withdrawal of water at will, so as to maintain it at the level most convenient to the industrial wants of the place, or to empty it altogether when it is necessary to cleanse the basin, pave the bottom, and furnish it with a fresh supply of oysters.

When these necessary works are completed, advantage is taken of the first spring tide to fill the basin. When the tide begins to ebb, the sluices are closed, so as to retain sufficient water in the basins; and while thus shut up, salt held in solution is deposited.

When the basin has been filled with sea-water for the necessary time, and the bottom is sufficiently impregnated with salt, it is emptied and left to dry; and now, the soil being prepared, it only remains to furnish it with oysters of a mellow and ripe age, in order to give them their green hue. Towards the month of September, at low water, the whole sea-side population of Marennes go to gather oysters on the pavement left uncovered by the ebbing tide, or by using a dredger in the deeper parts of the *claires* where the water still remains. A temporary magazine for the reception of the oysters thus gathered is erected on the banks, which the water revisits twice a day. The young are reserved for cultivation on the parks or *claires;* the fullest are sold for consumption in the neighbourhood; but the quantity of oysters raised at Marennes is insufficient to supply the demand. About a third of the provision intended for the *claires* comes from the coast of Brittany, of Normandy, and La Vendée. "These foreign oysters," says M. Coste, "never attain the fine flavour of those bred in the locality. It is necessary to keep them for a long time in the *claires* before they are sufficiently ameliorated, and, even when they become green, they retain traces of their primitive nature, remaining hard, in spite of the new qualities imparted to them by cultivation; a certain bitterness remains, which is easily distinguished

by the true amateur; it is the same with indigenous adult oysters. When they are taken at this stage of their existence the colouring does not succeed with them;—it is only, so to speak, the false brand used to give a speculative value to the merchandise. It is not enough that the mollusc should have a fine flavour; it must have the peculiar taste. It is not enough that it has the green hue; it is necessary that these qualities should pervade it from the earliest age, and that the culture of the *claires* should continue to the end." It is thus necessary that the oysters for the *claires* of Marennes should be selected when from twelve to eighteen months old, that the shells should be well-formed and free from all foreign bodies adhering to the surface. Being thus carefully picked out, the oysters are distributed over the bottom of the *claires* with a shovel, and afterwards so arranged by the hand that they may not touch each other when they increase in size; that they do not embarrass each other by the movements of their valves; and that nothing should interfere with the regularity of their forms. The young colony reposes under a sheet of water from twelve to eighteen inches deep, which is, as we have said, only renewed at spring tides, which reach the level. Nor are the oysters abandoned to themselves in these privileged beds while they are growing and ripening. They are objects of continual care and of special manipulation. The spring tides visit the *claires* charged with mud, which, if deposited in the motionless basins, would act as a poison to the young mollusc; hence the necessity of transporting them from one *claire* charged with mud into others free from such accumulations; and this is a process in constant operation, until the animals are finally gathered for consumption. Oysters deposited in the *claires* aged eighteen months should remain two years before they are ready for use; but three and even four years are required to give them the full degree of perfection which characterises the best products of the Marennes oyster-parks.

Oysters placed in the reservoirs in an adult state become green, it is true, in a very few days, but they never attain the exquisite flavour of those which have been bred in the parks, and have undergone the costly manipulation described from their earliest years.

The question arises, What is the colouring principle which is here in operation? The green colour is not general; it is shown principally on the branchiæ, upon the labial tentacles and intestinal canal; it is often rather undecided; and the colouring matter appears to differ chemically from all other known pigments of green colour. Must it be attributed to the soil of the *claire?* This is its most probable origin. But many naturalists insist that the colouring matter

proceeds from a green-coloured infusorial animalcule. Others have hazarded the opinion that it is a disease of the liver in our unfortunate bivalve which produces the colour. Bile secreted in excess by a diseased liver would give a green hue to the parenchyma of the respiratory organs of an animal rendered sick by the exceptional treatment to which it has been subjected. Of these three opinions, says M. Figuier, the first, as we have said, presents the greatest appearance of probability.

The system of oyster farms, which has worked admirably for the companies themselves, has proved of doubtful utility, so far as the oyster-eating public is concerned, as the following sketch of the Whitstable oyster farms will show. The oyster farm at Whitstable is co-operative in the best sense of the term, and has been in operation for many years. The company possesses large oyster grounds, and a fine fleet of boats kept for the purpose of dredging and planting the beds; it is established under the Joint-Stock Companies Act, but there is no other way of entrance into it but by birth, as none of the free dredgermen of the town can hold shares. When a man dies his interest in the company dies with him, but his widow, if he leaves one, obtains a pension. The affairs of the company are managed by twelve directors, who are called "the jury."

"The layings at Whitstable," to summarise Mr. Bertram, "occupy about a mile and a half square; and the oyster-beds have been so prosperous as to have obtained the name of the 'happy fishing grounds.' Whitstable lies in a sandy bay, formed by a small branch of the Medway, which separates the Isle of Sheppey from the mainland. Throughout this bay, from the town of Whitstable at its eastern extremity to the old town of Faversham, which lies several miles inland, the whole of the estuary is occupied by oyster farms, on which the maritime population, to the extent of 3,000 people and upwards, is occupied; the sum paid for labour by the various companies being set down at £160,000 per annum, besides the employment given at Whitstable in building and repairing boats, dredges, and other requisites for the oyster-fishing. The business of the various companies is to feed oysters for the London and other markets, to protect the spawn or floatsome, as the dredgers call it, which is emitted on their own beds, and to furnish, by purchase or otherwise, the new brood necessary to supply the beds which have been taken up for consumption."

We have hinted above that in oyster, as in other fisheries, a wasteful spirit of extravagance has hitherto prevailed. It appears,

however, that no rule can be laid down even as to the particular year in which the oysters will spawn, much less where it will be carried to; for, although the artificial contrivances adopted by Sergius Orata for saving the spawn are perfectly well known to the parties interested here, they have not hitherto been imitated; the practice of the companies and private owners of oyster-layers being to purchase their young brood from the dredgers and others who fish along the public foreshore and open grounds on the Kent and Essex coasts, and even as far north as the Frith of Forth. The little Bay of Pont, for instance, on the Essex coast, which is an open piece of water sixteen miles long and three broad, free to all, and which formerly yielded considerable supplies to Billingsgate, now gives employment to 150 boats, each with crews of three or four men, who are wholly employed in obtaining young brood—that is, oysters from eighteen months to two years old—which they sell to the oyster farmers. The result is, that the oyster farms have become a vast monopoly. By tacit consent they agree to supply the market at some £8 sterling per bushel; they pay the dredger one-fourth of that sum; and as the common fishing grounds are thus rendered mere nurseries of young brood, the lover of the bivalve must reconcile himself to pay a monopoly price for the precious morsel.

The system pursued at Whitstable, and other oyster-parks in the estuary of the Thames and Medway, is most efficient. The oysters reared in them, called "native," in contradistinction to those called "commons," which are bred in their natural beds, are justly considered to be very superior in flavour, although they are a mixed breed, being brought from every quarter to augment the stock.

The Thames, or "native" system, is as follows:—Every year each layer is gone over and examined by means of a dredge, successive portions being done day by day, till it may be said that each individual oyster has been examined; the young brood is detached from its bed, the double oysters are separated, and all kinds of enemies killed. During three days in each week dredging is pursued for "planting;" that is, for transference from one bed to another more suitable for their growth or fattening, and for the removal of the dead or sickly oysters and of mussels. On the other three days dredging for market takes place, when the more mature beds are dredged, and as many oysters are lifted as are required. Not only is this constant dredging of the beds themselves necessary, but the public beds immediately outside require the same care to keep them in a fit state, and free from enemies.

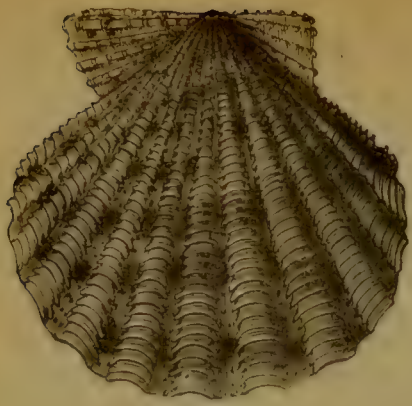
The same story of over-fishing and improvidence extends round

our whole coast. The far-famed Pandores obtained at Prestonpans, near Edinburgh, once so cheap, are becoming scarce and dear. The brood is caught and barreled for export to Holland and other places, especially the Thames oyster farms. English buyers pick the grown oysters for Manchester and other large provincial markets; and the Corporation of Edinburgh, the Duke of Buccleuch, and other proprietors of the foreshore, have just interfered in time to prevent the total destruction of the trade, when the wild song of the Cockenzie dredgerman might have been left to charm some future antiquary, as it is now said to charm the oyster into the dredge with its refrain :—

> "The herring it loves the merry moonlight,
> The mackerel it loves the wind ;
> But the oyster it loves the dredger's song,
> For it comes of a gentle kind."

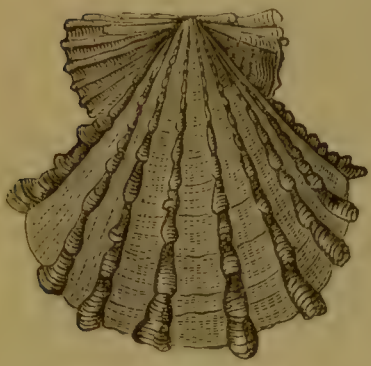
The Scallop-shell (*Pecten varius*) is round, nearly equal-sided, resting on the right valve, which is more convex, and marked with radiating ribs. Linnæus made the mistake of confounding with the *Ostrea* a great number of shells, which, by their channeled edges and surfaces, strongly reminded one of the arrangements of the teeth of a comb, whence their name of *Pecten*. They were well known to naturalists long before the time of Linnæus, under the name of *Pilgrims' shells*, a name which came into use from the practice which prevailed among pilgrims in the middle ages—we know not why—of ornamenting their habits and hats with the valves of some of the species.

The shell of the species of *Pecten* is in general nearly circular, more or less elongated, and terminated towards the summit in a straight line, forming a sort of triangular appendage called the ear, to which the hinges are attached. The valves are very regular, but with no resemblance to each other. In some species, the shell of which is closely shut, the lower valve is more or less convex than the upper one. In others, both valves are convex. The hinge is without teeth, and the ligament, which is intended to close the shell, is inserted into a triangular depression or dimple. The retractile muscles are unequal, and nearly central. The valves are not nacred inside, and are formed on their exterior surface of numerous fluted channels, which spring from a lobe more or less pointed at the summit, diverging towards the circumference. The edges are sometimes smooth, as in the Watered Pecten (*P. pseudamussium*, Fig. 174), but more frequently they are formed in strips or scales, as in the Smooth-shelled Pecten (*P. glaber*, Fig. 175). Upon the whole, however, the



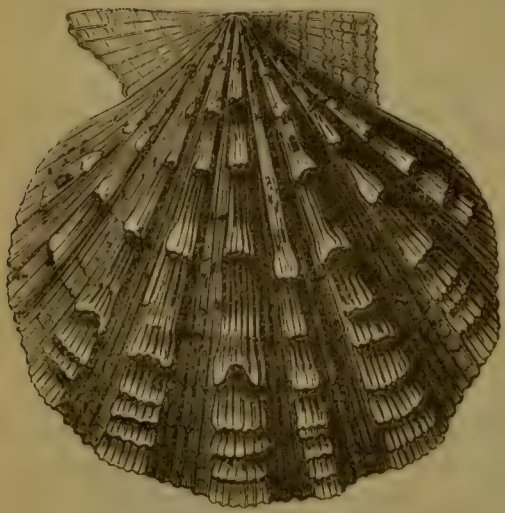
I.—Pecten pallium (Linn.).

II.—Pecten purpuratus (Lamarck.)



III.—Pecten foliaceus.

IV.—Pecten tigris (Lamarck.)



V.—Pecten nodosus (Linn.).

VI.—Pecten islandicus (Chemnitz.)

XVIII.—Pectinidæ.

Pectens are very variable, but always elegant in form; the colours are frequently lively and brilliant. In PLATE XVIII. some of the most striking forms are represented, as in Fig. I., the Ducal Mantle (*Pecten pallium*), an inhabitant of the Indian Ocean, remarkable for its elegant form, its twelve radiating stripes, diverging towards the circumference, the horizontal furrows of its salient scales, and the striking distribution of its white spots upon a bed of red and brown marble; Fig. II., the Purple Pecten; Fig. III., the Coral Pecten; Fig. IV., the Tiger Pecten; Fig. V., the Foliaceous Pecten; and Fig. VI., the Northern Pecten.

The animal which inhabits the shells belonging to this genus has

Fig. 174.—Pecten pseudamussium (Chenu).

Fig. 175.—Pecten glaber (Linnæus.)

the general form of the oyster, differing however from it in a remarkable manner. The edges of the mantle are furnished with multiplied fringes of simple tentacles, between which we find other tentacular appendages a little thicker, each terminating in a sort of small pearl, vividly coloured, which has been taken for an eye, and to which is attached a nervous thread. Another difference is that the branchiæ, in place of being connected to each other and the mantle lobes forming as in *Ostrea* a complete branchial chamber, here are crescent-shaped, and are quite unconnected posteriorly, and have excurrent canals. The mouth is provided with foliaceous lips, and a foot is present, somewhat finger-like, grooved, and byssiferous when young.

While the oyster shell is completely fixed to its bed, the Pecten is, on the contrary, perfectly free, and shifts from place to place, moving in the water even with a certain amount of agility; by smartly closing

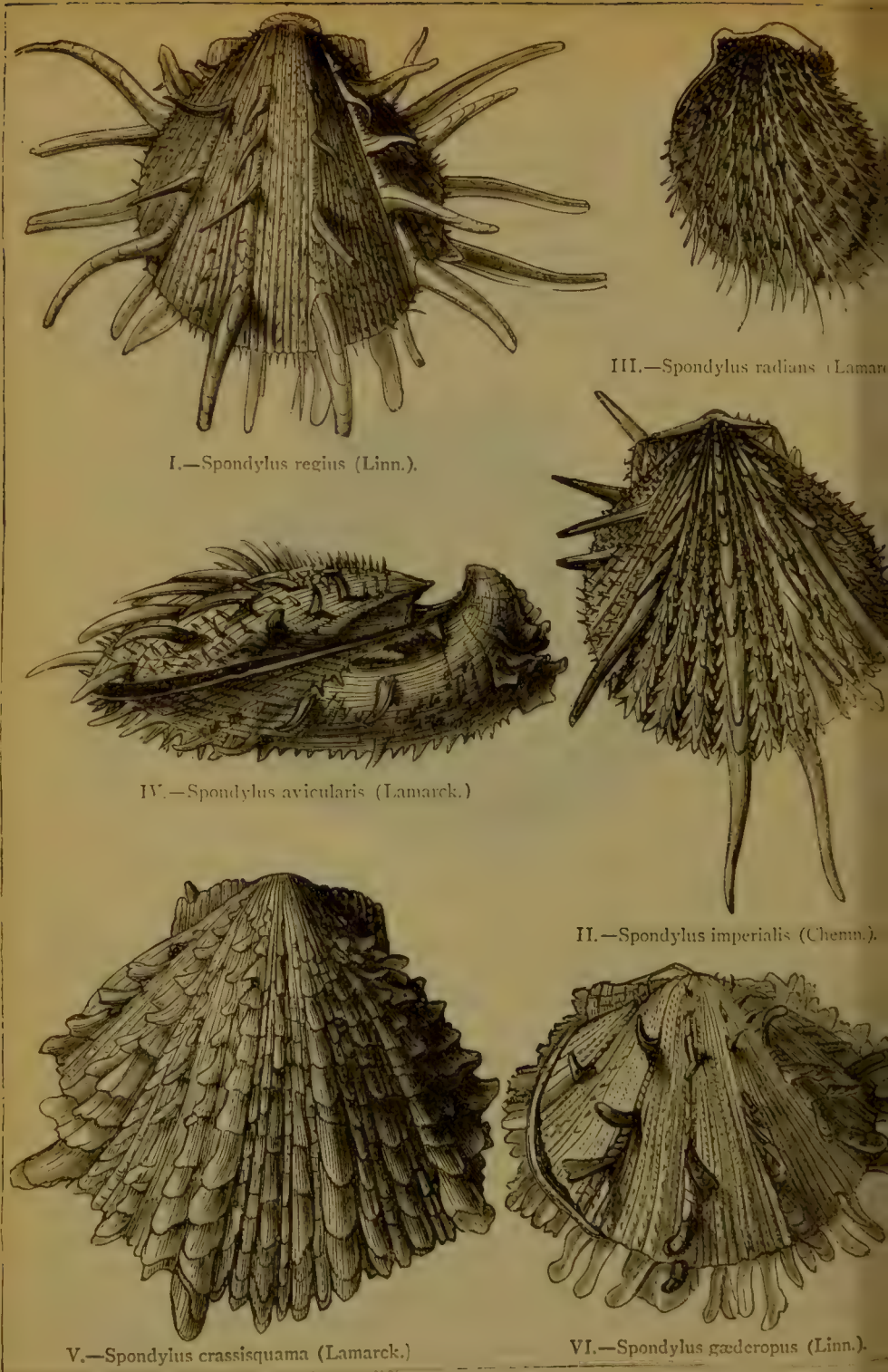
its half-opened valves and forcibly expelling the water, it moves backward by a sort of recoil; this action, repeated many times, compels the animal to move almost in spite of itself, and enables it to avoid danger, or directs its steps towards the spot it wishes to reach.

The Pectens, of which 176 species are described, are inhabitants of every known sea. Twenty species belong to Europe, among which we may mention *P. opercularis*, represented in Fig. 176; *P. glaber* (Fig. 175), and *P. nivea*. Fig. 177 represents the White-mantled

Fig. 176.—Pecten opercularis (Linnæus).

Pecten (*P. plica*, Linn.) of the Indian Ocean, and Fig. 178, the Concentric Pecten (*P. japonica*) of the Japan seas.

Among the Ostreadæ the shells of several species of the genus *Spondylus* are distinguished for their variety of form and the brilliant colours with which they are decorated. This makes them much sought after by amateur collectors, and procures for them a high price. The shell of *Spondylus* is solid and thick, with unequal adherent valves, nearly always bristling with spines, forming a very peculiar kind of ornamentation to the valves; the hinges have two very strong teeth. The animals which inhabit this shell resemble the oyster in many respects, but they still more closely resemble the Pectens. The edges of the mantle are provided with two rows of tentacles, the exterior row being, many of them, furnished at their extremities with coloured tubercles. As examples, we note several



XIX.—Spondylus.

pecies of these bivalves for representation. *Spondylus regius* Fig. I., PLATE XIX.) is, perhaps, the most remarkable for its immense pines. *Spondylus radians*, Lamarck (Fig. III.), is noted for its legant form. *Spondylus avicularis* (Fig. IV.) shows remarkable nequality in the valves. *Spondylus imperialis*, Chenu (Fig. II.), has ong projecting spines, like feet; and the Scaly Spondylus (*S. crassisquama*, Fig. V.) is covered with scales arranged like so many roofing-iles.

Like *Ostrea*, the genus *Spondylus* is frequently found firmly rooted

Fig. 177.—Pecten plica (Linnæus).

Fig. 178.—Pecten japonica (Gmellin).

o rocks and other submarine bodies, and, oftener still, heaped one upon the other, like herrings in their barrel.

These animals belong essentially to the seas of warm countries. We find them, however, occupying considerable space in the Mediterranean, where the *S. gæderopus* (Fig. VI.) abounds.

But the most remarkable species of all is assuredly *Spondylus regius* (Fig. I., PLATE XIX.) This species is a native of the Indian Ocean, and at one time there scarcely existed three fragments of this rare shell in the museums of Europe. M. Chenu relates in one of his books an anecdote which would prove—if any proof were necessary—how far the desire of a collector to obtain possession of some rare and costly specimen will carry him in order to attain his object. "M. R——," says M. Chenu, "was Professor of Botany to the Faculty of Paris, and was, as sometimes happens, more learned than rich; he wished, on the invitation of a stranger, to purchase one of these shells at a very high price, which might be from 3,000

to 6,000 francs; the bargain was made, and the price agreed upon; it was only necessary to pay. The money in the Professor's hands made only a small part of the sum the merchant was to receive for his shell, and he would not part with it without payment. M. R——, now consulting his desire to possess the shell more than his weak resources, made up secretly a parcel of his scanty plate, and went out to sell it. Without consulting his wife, he replaced his silver plate by articles of tin, and ran to the merchant to secure his coveted Spondylus, which he believed to be *S. regius*.

"The hour of dinner arrived, and we may imagine the astonishment of Madame R——, who could not comprehend the strange metamorphosis of her plate. She delivered herself of a thousand painful conjectures on the subject. M. R——, on his part, returned home happy with his shell, which he had committed to the safe custody of a box placed in his coat pocket. But, as he approached the house, he paused, and began for the first time to think of the reception he might meet with. The reproaches which awaited him, however, were compensated when he thought of the treasure he carried home. Finally, he reached home, and Madame R——'s wrath was worthy of the occasion; the poor man was overwhelmed with the grief he had caused his wife; his courage altogether forsook him. He forgot his shell, and, in his trepidation, seated himself on a chair without the necessary adjustment of his garment. He was only reminded of his treasure by hearing the crushing sound of the breaking box which contained it. Fortunately, the evil was not very great—two spines only of the shell were broken; but the good man's grief made so great an impression on Madame R——, that she no longer thought of her own loss, but directed all her efforts to console the simple-minded philosopher."

The variation in the number and direction of the spines is a striking feature in Spondylus. When the whole lower surface adheres to branches of coral—a very frequent occurrence—they are confined to the upper valve; but when a part only of the valve is so adherent, the whole surface becomes covered.

CHAPTER XIII.

BRACHIOPODA.

WHILE it is out of the province of this work to enter into any lengthy arguments as to the position of this class; while we treat of them here immediately after the Conchifera, it is not in ignorance that they would be more justly placed among the Molluscoida, probably very near to the Tunicata. They differ from ordinary bivalves in being always *equal sided*, but never quite *equi-valved*. Their valves are respectively dorsal and ventral. The ventral valve is usually largest, and has often a prominent beak, by which it is attached, or through which the organ of adhesion passes. The dorsal valve is always the smaller, and is free and imperforate. The valves are articulated by two curved teeth, which are so complete that the valves cannot be separated without injury. A few genera have no hinge. In *Crania* and *Discina* the lower valve is flat; the upper like a limpet; while the valves of *Lingula* are nearly equal, and have been compared to a duck's bill. In the Conchifera the sliding of the valves is well guarded against by means of hinges with teeth and sockets; but in the Brachiopods the same end is apparently attained by means of muscles. The blood system is not very complex, and does not differ very greatly from the same system in the Tunicates. The Brachiopods are all natives of the sea; but little is known as to their development. Of all mollusca they enjoy the greatest range, both of climate, of depth, and time. A large number of the genera contain only extinct forms; indeed of the 1,842* species formerly known, a few types of but a small number of genera only are left, numbering in all 102. The Terebratulidæ are best represented. There were once 300 or 400 species of this family; there are now not more than sixty-seven in the seas of the world. The difference between the past and the present is especially striking, when we compare the recent and fossil species of Europe. Among no other class of shells

* "Woodward's Manual," p. 135.

has there been such a wholesale extinction of species. The great family of Spiriferidæ is wholly extinct, and of 400 species belonging to the family of the Rhynconellidæ only four are now living. Species of the curious genera Crania, Discina, and Lingula are still living, and are mostly found in the seas of the southern hemisphere.

The *Brachiopoda* contain the following families :—

I. *Lingulidæ*, containing Lingula and other genera.
II. *Discinidæ*, containing Siphonotreta and Discina.
III. *Craniadæ*, containing Crania.
IV. *Productidæ*, containing Chonetes and Productus.
V. *Orthidæ*, containing Calceola, Davidsonia, Strophomena, and Orthis.
VI. *Rhynconellidæ*, containing Atrypa, Pentamerus, and Rhynconella.
VII. *Spiriferidæ*, containing Uncites, Retzia, Athyris, and Spirifera.
VIII. *Terebratulidæ*, containing Thecidium, Argiope, Terebratella, and Terebratula.

CHAPTER XIV.

CEPHALOUS MOLLUSCA.

GASTEROPODA.

We take leave of our little friends the Headless Mollusca or *Acephala*, and direct our attention to those molluscs to which Nature has been more generous, and which are furnished with a head. This head, however, is still carried humbly; it is not yet *os sublime dedit;* it is drawn along an inch or so from the ground, and in no respect resembles the proud and magnificent organ which crowns and adorns the body of the greater and more perfectly organised animals.

The organisation of the Cephalous Mollusca present three principal types, which has led to their being divided into three classes, after their more salient characteristics of form and locomotive apparatus; namely, *Gasteropoda*, *Pteropoda*, and *Cephalopoda.*

In the class *Gasteropoda* (from γαστὴρ, *belly*, ποῦς, gen. ποδὸς, *foot*), locomotion is effected by means of a flattened muscular disk, placed under the belly of the animal, by the aid of which it creeps. The Snail (*Helix*), the Slug (*Limax*), and the Cowrie (*Cypræa*), are types of this class.

In the *Pteropoda* (from πτερὸν, *wing*, and ποῦς, *foot*), locomotion is effected by appendages in the form of wings, or membranous swimming fins, placed on each side of the neck. The *Hyalea* and *Clio* are types of this class.

In the *Cephalopoda* (from κεφαλὴ, *head*, and ποῦς, *foot*), locomotion is effected partly by means of a set of arms, or tentacles, which surround the mouth in numbers more or less considerable. The Cuttle-fish (*Sepia*), and the Poulpes (*Octopus*) are types of this last class.

The Molluscous Gasteropoda have the organs of respiration formed for aërial respiration, or for respiration under water.

This physiological arrangement involves important differences in

internal organisation in these molluscs, and renders it convenient to divide them into two secondary groups; namely, *Pulmonary Gasteropods*, which breathe in the air, and by a kind of lung, and *Non-pulmonary Gasteropods*, which breathe in the water, by means of branchiæ or gills, or we may consider the Gasteropoda, as they were divided by Milne-Edwards, into four orders. Firstly, NUCLEO-BRANCHIATA, animals which float on the surface of the ocean; they are diœcious, or in separate sexes, and the nervous centres are widely separated in the body. The first family of this order is Atlantidæ, of which the types are the fossil genus Bellerophon and the recent genus Atlanta. The second family is Firolidæ, the typical genera of which are Carinaria and Firola. The shell in Carinaria or Glass Nautilus is shaped like the bonnet-cap shell, Pileopsis. It is as transparent as glass; and although now very common, was formerly one of the shells most highly-prized by collectors. The shell covers only a very small portion of the body.

The second order of Gasteropoda is OPISTHO-BRANCHIATA, and is divided into two sections, the Nudibranchiata and the Tectibranchiata. The Nudibranchiata have no shell except in the larval state; they mostly live at the bottom of the sea on rocky shores, but a small number swim on the surface. They are remarkable for the variety of their form and vivid colouring, being the most beautiful of all molluscous animals; they may truly be called the caterpillars of the sea, for their branchiæ remind us of the spines with which many lepidopterous larvæ are covered.

The first family of the Nudibranchiata section is *Elysiadæ:* typical genera, Limapontia and Elysia.

The second is *Phyllirhoidæ;* typical genus, Phyllirhoe.

The third is *Æolidæ;* typical genera, Glaucus, Alderia, and Æolis.

The fourth is *Tritoniadæ;* typical genera, Scyllæa and Tritonia.

The fifth is *Doridæ;* typical genera, Idalia, Triopa, and Doris.

The first family of the second section, *Tectibranchiata*, is *Phyllidiadæ;* typical genera, Diphyllidia and Phyllidia.

The second family is *Pleurobranchidæ;* typical genera, Umbrella and Pleurobranchus.

The third family is *Aplysiadæ;* typical genera, Dolabella and Aplysia.

The fourth family is *Bullidæ;* typical genera, Scaphander, Acera, Cylichna, Amphisphyra, and Bulla.

The fifth family is *Tornatellidæ;* typical genera, Tornatina and Tornatella.

In the order of the Opistho-branchiate Molluscs we reach a group

of Gasteropods very numerous, both in species and in special types, all the species of which respire by the aid of branchiæ or gills.

The Tectibranchiata have the gills attached either to the right side of the body or upon the back, arranged in the form of leaflets, more or less divided, but not symmetrical, and nearly covered by the mantle.

Some species of the genus *Aplysia* were known to the ancients under the name of sea-hares (*Lepus marinus*), from some fancied resemblance to the terrestrial hare. They were objects of profound horror, inspired either by their singular form, or from an acrid, caustic, and inodorous liquid which they secrete. A magic influence was attributed to them; they were supposed, for instance, to have influence over the female heart. It is not easy, however, to explain the evil renown acquired by an animal which is known to be gentle and even timid. They are naked and fat, somewhat resembling the Limnæa in their oval, elongated form, their thickness in the dorsal region, and their peculiar locomotion. Their head, which is very indistinct, is furnished with four tentacles, the anterior two of which are the largest, and somewhat resemble the ears of a hare. The eyes are found at the base of the posterior tentacles. These characters are observed in *Aplysia depilans* (Fig. 179). *Aplysia inca* shows also the same arrangement (Fig. 180). In this family the mollusc is much more important from its volume than from its shell, which is internal, rudimentary, and horny, and is placed just over the branchial cavity. In Fig. 181 we have this small and thin cartilaginous shell as it exists in *A. inca* figured.

Species of the genus Aplysia are found nearly in every region of the globe, not only upon the shores of continents, but on every island shore. They commonly inhabit sandy and muddy shores of small depths, or even their rocky recesses, or under shelter of the stones which have fallen from the cliffs. Their eggs form great long filaments, which are discharged in immense numbers, and which fishermen call sea-worms.

They feed upon certain algæ, with which the bottom of the sea is covered; but they eat also small marine animals, such as the naked molluscs, annelids, and crustaceans.

We are the less astonished to see the Aplysia so gluttonous when we learn how liberally Nature has accorded to them organs of mastication, trituration, and digestion. Their mouth is formed of thick and muscular lips; a very long œsophagus or gullet succeeds, and this œsophagus does not communicate with a single stomach, but with four—one enormous membranous crop, an exceedingly muscular

gizzard, with two accessary pockets, one of which terminates in the form of sac. The gizzard has thick walls, and is furnished on the internal wall with cartilaginous quadrangular pyramids, the summits of which intertwine. This apparatus is intended to bruise the food

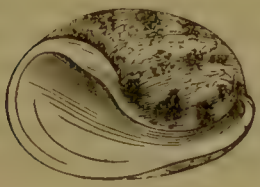
Fig. 179.—Aplysia depilans (Linn).

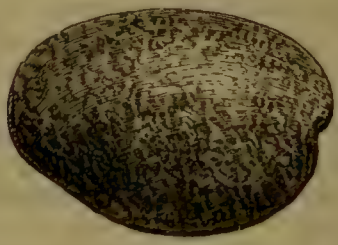
Fig. 180.—Aplysia inca (D'Orbigny).

Fig. 181.—Shell of Aplysia inca.

when it reaches the third stomach. It is also armed with little hooks, the curvature of which is directed towards the entrance of the gizzard.

The genus *Bulla* differs materially from the genus *Aplysia*. The species have a well-developed shell, the form of which is elegant





Figs. 182 and 183.—Bulla ampulla (Linnæus).

and delicate in structure; their brilliant colours, consisting of red, black, or white bands, separated by many varied tints, cause these little shells to be much sought after for ornamental collections. The shell itself is oval or globulous, rolled up in a scroll, smooth, spotted, very thin and fragile, with a concave spire, umbilicate, open in all its length, with a straight, wide, and cutting edge. The gills of the animal are placed upon the back, a little to the right and behind, but

well protected by the shell; its stomach, which alone fills a great part of the cavity of the body, presents the peculiarity, already noted in the genus Aplysia, of being furnished with bony pieces, evidently intended to grind the food.

The Bullæ can swim with facility in deep water, but they evidently

Fig. 184.—Bulla oblonga (Adams).

Fig. 185.—Bulla aspersa (Adams).

Fig. 186.—Bulla nebulosa (Gould).

prefer the shallows and a sandy bottom, feeding upon smaller molluscs. They are found in every sea, but they abound chiefly in the Indian Ocean and Oceania. Some species, however, such as *Bulla ampulla* (Figs. 182 and 183), the shell of which is shaded grey and brown, and the Water-drop (*Bulla hydatis*), inhabit European seas. *Bulla oblonga* and *Bulla aspersa* (Adams), and *Bulla nebulosa* (Gould), represented in Figs. 184, 185, and 186, are also well-known species.

CHAPTER XV.

PULMONIFERA OR PULMONARY GASTEROPODS.

THE *Pulmonary Gasteropods* comprehend those molluscs which, as we have said, live in the air and breathe the natural atmosphere. Their respiratory organ is a cavity, in the walls of which the blood-vessels form a complicated network. The air enters this cavity through an orifice, which the animal opens and shuts at will—a species of lung, in short, which is placed upon the side of the animal. They are both terrestrial and aquatic animals. In the latter case, they must come to the surface of the water in order to breathe, like the seals and whales among the mammals.

The Pulmonifera, the third order of Gasteropods, comprehends those animals which live in and breathe the air.

It is divided into two sections; I. the Operculata, or land-snails, whose shells are closed by an operculum; and (II.) the In-Operculata, or land-snails without operculum.

The first section, Operculata, is divided into two families; first, Aciculidæ, of which the typical genera are Geomelania and Acicula; and the second, Cyclostomidæ, of which the typical genera are Pupina, Cyclophorus, and Cyclostoma. Cyclostoma is perhaps the best known genus; the mouth is circular, the name being derived from *cyclos*, circle, and *stoma*, mouth.

The second section, In-Operculata, contains five families:—

I. *Auriculidæ;* typical genera, Conovulus, Carychium, and Auricula.
II. *Limnæidæ;* typical genera, Planorbis, Physa, Ancylus, and Limnæa.
III. *Oncidiadæ;* typical genera, Vaginulus and Oncidium.
IV. *Limacidæ;* typical genera, Testacella, Arion, and Limax.
V. *Helicidæ;* typical genera, Clausilia, Pupa, Achatina, Bulimus, Succinea, Vitrina, and Helix.

It will be desirable to treat of a few of these families a little in detail, and we will commence with that of the Limnæidæ, which is

ne second family of the In-Operculata series. *Limnæa*, *Planorbis*, nd *Physa*, are among the principal genera of this family.

Species of the genus Limnæa live in great numbers in the fresh vaters of all countries, particularly of temperate climates. They annot remain long under water, being compelled frequently to rise o the surface in order to breathe atmospheric air. They are even observed, by a mechanism not very well understood, to turn ipside down, in such a manner as to present themselves feet ippermost, and to move slowly along in this position, creeping, as it vere, through the water. It is difficult to comprehend how the movible liquid bed upon which the animal operates can offer resistance enough to permit of its creeping as if it were on a solid resisting body; out it seems to produce the movement with the assistance of its foot, which is broad and thick, and shorter than the shell.

Limnæa is characterised by having a large flat head, from each side of which issues a triangular contractile tentacle, carrying at its base and on the inner side an extremely small dot, or eye. The whole of the somewhat considerable mass of the body is contained in a thin diaphanous shell (Fig. 187), the turns in the spiral of which are generally elongated, the body whorl being larger than all the others, and the aperture is rounded in front. The interior of this is occupied by the respiratory cavity, which communicates outwardly by an opening analogous to that which exists in the snail. This opening dilates and contracts in such a manner as to receive the air into the cavity, and exclude water when the animal feeds itself under it. The mouth is a transverse slit between two rather thin lips, and is armed with small lingual teeth. When the animal sallies from its shell, it has the appearance of a short trumpet. The mouth is armed with a horny dentated crescent-shaped upper mandible; the lingual membrane lies at the bottom of the slit, and is flat, oval shaped, with the central teeth inconspicuous, and the lateral ones numerous and similar.

Limnæa, aided by its complicated buccal apparatus, is enabled to feed on vegetable substances, such as the leaves of aquatic plants, which it cuts and bruises with its teeth. They are very active in the spring season, towards the end of which they deposit their spawn, which at this period is found in the form of little oval or semi-cylindrical masses adhering to floating bodies, or on stones and aquatic plants, glittering and transparent as crystal. When winter sets in, the Limnæa of our climate fall into a state of torpor, and sink, more or less deeply, into the mud of the lakes, marshes, rivers, or brooks, which they inhabit.

They are of great utility, both to feed fishes and aquatic birds, and also as scavengers of the decaying vegetation of brooks.

The genus Planorbis has an organisation analogous to Limnæa, of which it is the faithful companion in stagnant waters. Their shells (Fig. 188) are thin, light, and disc-like in form, rolled round their planes in such a manner as to render all the turns of the spiral visible from above as well as below; they are concave on both sides, with an oval, oblong-shaped opening, which is furnished with a thin peristome. The animal is conformable to the shell in shape. The visceral mass forms

Fig. 187.—Limnæa stagnalis (Linnæus).

Fig. 188.—Planorbis corneus (Linnæus).

Fig. 189.—Physa castanea (Lamarck).

a very elongated cone, which follows the spiral turns of the shell. The foot, or abdominal locomotive mass, is short, and very nearly round. The head is sufficiently distinct, and furnished with two very long filiform, contractile tentacles, having at their base, and on the inner side, two small organs, which look like eyes. The mouth is armed in the upper part with cross-cutting teeth, and in the lower part with a tongue, bristling with a great number of subquadrate and bi- or tri-cuspid teeth.

In habits Planorbis resembles Limnæa; it creeps like it on the surface of solid bodies, and swims in the water with the foot upwards and the shell down. It feeds on similar substances, and its eggs are

also collected in gelatinous masses. It passes the winter in a state of torpor, buried in the mud of the rivers it inhabits.

The principal native species is *Planorbis corneus* (Fig. 188), which is common everywhere in Great Britain.

Another genus of these molluscs, which occupies our fresh-water rivers, and often swims with the head down and foot up, is represented by the genus *Physa*. *Physa castanea* (Fig. 189) has an oval, oblong, or nearly globular shell, very thin, smooth, and fragile, opening longitudinally, narrow above, with the right edge sharp; the last turn of the spiral being the largest of all. The animal appears to be intermediate in form between Planorbis and Limnæa; it is oval in form, and unrolls itself like the Limnæa, but its tentacles, in place of being triangular and thick, like the latter, are elongated and narrow, like those of Planorbis. These little inhabitants of the fresh water swim with facility, the foot upwards, the shell below, and like Limnæa, they feed on vegetables.

The fourth family, Limacidæ, containing Testacella and Limax, consists of terrestrial pulmonary molluscs, entirely naked, or having only a very small shell. The species of the genus Limax vary very considerably in appearance, and in consequence of their extreme variability we find even individuals of a species differing much. When seen creeping along on the surface of the soil, they have nearly the form of a very elonglated ellipse, at one extremity of which is the head; the surface of the body in contact with the earth is flat, the other convex. Towards the anterior extremity, and upon the middle of the back, a portion of the skin projects as if it were detached from the body, and is ornamented with transverse stripes of various convolutions. This part is named the cuirass, or buckler, under which the animal can hide its head. The mouth is a transverse opening in the front of the head; above are two pairs of tentacles, or horns, immensely retractile, cylindrical; the lower tentacles are the shorter; the upper terminating in small black points, as in *Helix*, which are regarded as eyes.

Upon the right side of the body, and hollowed in the thickness of its edge, which is large and contractile, is the respiratory orifice, whose function it is to give access to the atmospheric air, it abuts on an internal cavity, also large, which is the pulmonary sac. The outer skin, or epidermis, is rayed in brownish furrows, its surface covered with a viscous glutinous substance, which permits of the animal creeping up the smoothest surfaces, locomotion being produced by the successive contraction and extension of the muscular fibres of the foot.

The internal organisation of Limax is analogous to that to b described in the snails. The organs of taste and smell in the Lima ceans differ only slightly from those organs in Helix. They are said like the snails, to be deaf, and nearly blind. They love humid places they lodge themselves in the holes of old walls, under stones, or hal decomposed leaves, in the crevices of the bark of old trees, an even underground, coming forth only at night and in the morning especially after soft showers in spring and summer. In the garden after one of these soft showers, many of these little creatures are sur to be met with in the more shaded alleys.

The slugs are mostly herbivorous. They seek, above all, fo young plants, fruits, mushrooms, and half-decayed vegetables. The

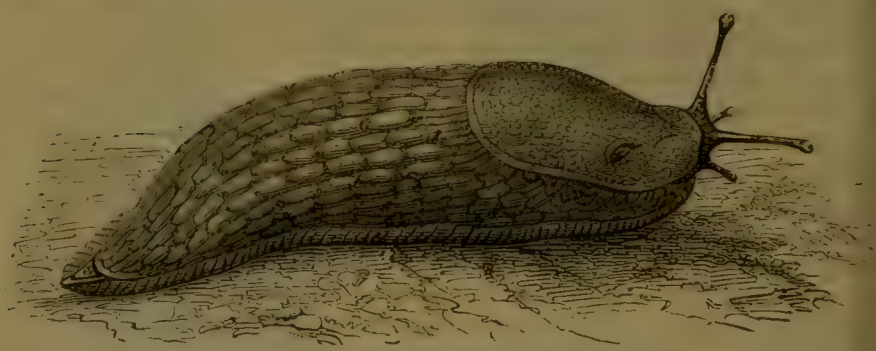


Fig. 190.—Limax rufus (Linnæus).

are very voracious, and cause great ravages in gardens and young plantations, and many are the devices of the watchful gardener to destroy them. Lime and salt are their abomination; ashes and fine sand they avoid. They dislike the noonday sun, and the gardener knows it; he arranges little sheltering tiles, or planks of wood and stone, under which they retire, where they are surprised to their destruction.

There are about fifty known species of the genus Limax. Some are remarkable for their very striking colours. *Limax rufus* (Fig. 190) is common in woods, and well known for its large size and its colour of rich yellowish red; it is known all over Europe, from Norway to Spain.

Among the Limacidæ not altogether destitute of external shells, we find *Testacella haliotoides* (Fig. 191), which is provided with a very small shell placed at its posterior extremity, just over the pulmonary cavity. This shell becomes more important in *Vitrina*, already spoken

of as forming the point of transition between Limax and Helix. This passage from Limaceans entirely destitute of shells to those furnished with a very small shell, as in *Testacella*, is very exactly indicated by Nature. *Limax rufus*, spoken of above, presents, under the posterior part of the cuirass, calcareous, unequal, isolated granulations, which are, so to speak, the elements, as yet internal, of a shell which is on the point of being built. Other species in the same genus present under the cuirass a little rough, imperfect scale, which seems to be produced by a great number of those calcareous granulations, which show themselves in an isolated state in *Limax rufus*.

The Helicidæ is the last family we have to consider of this order.

It is only necessary to witness the snail as it creeps along the gravel walks of a garden, or in the damp alleys of a park, in order to see that it is a being of higher organisation than the headless molluscs. The common snail (*Helix aspersa*) goes and comes; it roams and

Fig. 191.—Testacella haliotoides (Draparnaud).

saunters after its own peculiar manner, searching for its food or its pleasure; it has a head and two prominent tentacles, which feel and seem to express their sensations; it has nerves, a brain, a strong mouth, and a well-formed stomach.

Without possessing a high order of intelligence, the snail is by no means an imbecile; it knows very well how to choose a tree the fruit of which is agreeable to it. A fine cluster of grapes, a succulent pear, which the horticulturist devours with his looks, and hopes to devour otherwise, is sure to be the identical fruit which will be chosen by our enlightened depredator the snail.

The body of the snail is oval, elongated, convex above, flat below. The convex or upper surface of the body is rugged, in consequence of the existence of numerous tubercles projecting slightly, and separated by irregular furrows; its anterior is terminated by an obtuse head, its posterior more flat and less pointed. All the flat portion, thick and soft, and upon which the animal moves itself by a creeping motion, bears the name of "foot." The head is not really very distinct, especially in the upper part; but the organs with which it is provided are prominent. These organs are in reality tentacles, although they are more popularly known as *horns*, especially among

children—those charming ignoramuses—who have been taught to repeat the well-known couplet—

> "Snail, snail, come out of your hole,
> Or else I'll beat you black as a coal,"

which finds its counterpart in all European languages. There are two pairs of these tentacles or horns; one pair quite in front and above, and another smaller and less forward. The first, or upper pair, is distinguished by its size, and also by a black spot or point at their extremity, which are said to be the eye-specks of the snail. These tentacles differ in many respects from the same organs in other molluscs; they are retractile, and can be drawn altogether within the animal into a sort of sheath, by the contraction of the muscles.

At the anterior extremity of the head we find a sort of plaited opening, which is the mouth; it is of moderate extent, closed in front by two lips, and armed with two shear-like organs of horny consistence, one of them being a sort of rasp, which occupies the place of the buccal cavity, and may be called a tongue; the other is a median jaw, placed transversely in the membranous walls of the palate, terminating in a free edge, armed with small teeth. This cutting blade, however, executes no movement; but the lingual organ, pressing all alimentary matter forcibly against its lower edge, effects their mastication, and enables it to dispose of fruit, tender leaves, mushrooms, and other substances easily divided.

At the bottom of the mouth is an œsophagus, or gullet, to which succeeds a stomach of moderate size. The intestine lies in folds round the liver, which is divided into four lobes, and terminates in a special orifice.

The little lung of the snail is placed in a cavity, vast for its size, just above the general mass of the viscera, and occupies all the last spiral turn of the cavity.

The mechanism of respiration is as follows: The animal inhales the air into its lung by forcibly dilating the pulmonary orifice, which lies in the largest spiral turn of the shell. In order to expel the air respired by the lung, it withdraws its body into the narrower part of the shell, where it gathers itself up completely, even to its head and feet, and by this compression of all its little being it expels the air which fills it. These respiratory movements, however, are not regular, but succeed each other only at certain intervals. Life would be too hard for the poor snail were it passed in such violent efforts as would be necessary if it respired as the larger animals do. In its

case the breathing is intermittent and imperfect; it is merely a rough attempt, as it were, at respiration, which becomes perfect in some of the higher branches of the animal kingdom.

The snail has a heart, consisting of a ventricle and auricle, connected with a well-developed arterial vascular system, while the venous system is imperfect. In short, the blood only returns from the various parts of the body to the respiratory apparatus, after traversing *lacunæ*, or air-cells, existing between the several organs. The blood of the snail is a pale rose colour, slightly tinted with blue.

The snail has a rudimentary brain, composed of a pair of thick ganglions, situated above the œsophagus, which is in connection with another pair of ganglions placed below, and these two together form a sort of collar, or ring, around the œsophagus. From this ring spring a great number of nervous cords, which are distributed to the mouth, the tentacles, the lung, and the heart. The skin, in those parts covered by the shell, exhibits great sensibility; it receives a considerable number of nervous filaments, so that the sense of touch ought to possess extreme delicacy.

The tentacles, the skin of which is so fine and so sensitive, are the organs of touch. Other functions are sometimes attributed to them; the anterior tentacles are sometimes considered to be the organs of smell. This, at all events, is certain, that the snail is very sensible of strong odours, and is easily attracted by many plants the odours of which please it.

The black points which terminate the first pair of tentacles have been considered as eyes; but the existence of a visual organ in the snail is still disputed by some. They are quite insensible to sudden changes of light; they always travel in the dark, and never recognise obstacles placed before them. We may add that the snail is destitute of all organs of hearing. No noise appears to affect it, at least till the noise is so near as to agitate the air which immediately surrounds it. Indeed, the snail has few senses; the poor creature is at once blind, deaf, and dumb.

The snails are male and female in the same individual, or hermaphrodite. Their eggs are roundish, heavy, and of a whitish colour. The animal deposits them on the soil in little irregular heaps; at other times it deposits them one after the other, like the grains of a chaplet, in holes which it digs in the soil, or in the natural excavations created by moisture. The eggs are even found in the hollows of old trees, and in fissures of walls or rocks.

When the young snail issues from the egg, it is already provided with an extremely thin membranous shell. The timid and tender

youth is conscious of its weakness, and full of humility. It rarely trusts itself out of the obscure hole in which it was hatched; when it does, it is only at night, dreading the desiccating air, and above all, the sun's rays, even with the house it always carries with it for shelter.

This calcareous and velluted house is spiral, which the animal has the inappreciable advantage of transporting without fatigue. It is light, and sometimes quite disproportionate to the body of the animal, which it covers only in that part which contains the viscera and respiratory organs.

The form of the shell is generally much variegated. Some are flattened, others are orbicular or globose; in some the spiral is very pointed. The edges of the shell are sometimes simple, sharp, and pointed; others, on the contrary, thick and inverted, presenting an edging of great solidity. The spire is generally rolled up from right to left. A Helix shell, the spiral of which follows the inverse direction, that is, from left to right, is a rarity much sought after by amateurs.

The ancients held snails in special esteem for the table. The Romans had many species served up at their feasts, which they distinguished in categories according to the delicacy of their flesh. Pliny tells us that the best were imported from Sicily, from the Balearic Isles, and from the Isle of Capri, the last dwelling-place of the aged Tiberius; the largest came from Illyria. Ships proceeded to the Ligurian coast to gather them for the tables of the Roman patricians. The great consumption led to the establishment of parks (*Cochlearia*, Varro; *Cochlearum vivariá*, Pliny), in order to fatten the animals, as is now done with oysters. They were fed for this end upon various plants mixed with soup; when it was desired to improve the flavour, a little wine and sometimes laurel leaves were added. These parks were formed in humid shady places surrounded by a fosse or a wall. Pliny has even transmitted to us the name of the inventor of the *Cochlearia*, a certain Fulvius Hispinus. Addison describes, with details, one of these establishments kept up by the Capuchins at Fribourg in Switzerland, in imitation of the ingenious Roman gourmet we have named.

Among the Romans snails were served at the funeral repast. Certain heaps of their shells, which are found in the cemetery of Pompeii, are the remains of those funeral festivities with which the inhabitants of the buried city honoured the tombs of their friends and relations

The practice of eating snails had fallen into disuse in Europe when, in the seventeenth century, John Howard the philanthropist began to collect them with the view of re-introducing them as human food. He chose *Helix Varronis*, which was probably the species cultivated by the Romans; it surpasses all those of Europe in size, and was found plentifully in the district of Bagnes, in the Valois. Howard, having procured the species from Bagnes, found them increase so rapidly that the crops were likely to be devoured by the swarms of molluscs thus brought together, and steps were at once taken to destroy them. In other parts of Europe the snail continues to be sought for as an article of luxury. They are consumed at

Fig. 192.—Helix aspersa (Muller).

Vienna in great numbers during Lent, supplies being brought from the Swiss canton of Appenzell. At Naples a soup made from *Helix nemoralis* is sold publicly to the strange population with which the streets of that city swarm, for the king's pavement is their bed-chamber, dining-saloon, and work-room. In France snails are a valuable resource to the poor in the southern departments.

The flesh of all the species of snails is not alike in a culinary point of view. Amateurs class as first in quality *Helix vermiculata*, called at Montpellier the Little Hermit, because it buries itself so deeply in its shell. *Helix aspersa* (Figs. 192, 193, 194) is thought to be more tender and delicate. In Provence a species is called *tapada*, that is, "closed," from the cretaceous deposit with which it closes its shell.

In the north of France and round Paris *Helix pomatia* is the

favourite culinary snail (Fig. 195). This is the species which is used as a speaking sign-board over the doors of the wine-shops and

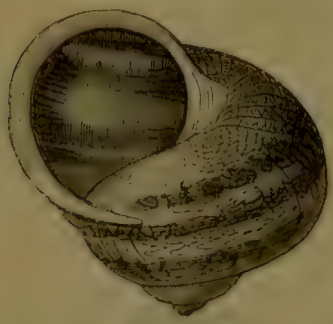


Fig. 193.—Helix aspersa (Müller).

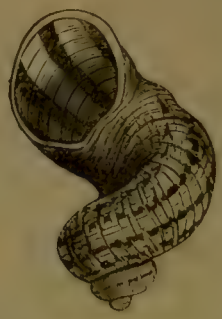


Fig. 194.—Helix aspersa (Var. Scalaris).

small restaurants in the neighbourhood of the Halles, at Paris. Its shell is globose and tun-shaped, very solid, marked with irregular

Fig. 195 —Helix pomatia (Linnæus).

transverse stripes of a brownish rust colour, with bands, often nearly effaced, of a deeper tint, and of the same colour. The animal is large, of a yellowish grey, and covered with elongated irregular tubercles.

Besides *Helix pomatia*, according to Moquin-Tandon, they eat in the north of France *Helix sylvatica* and *H. nemoralis;* at Montpellier, as we have already said, *H. aspersa* and *H. rhodostoma;* at Avignon, also, these, along with *H. vermiculata*, are favourites. In Provence,

Fig. 196.—Helix Mackenzii (Adams).

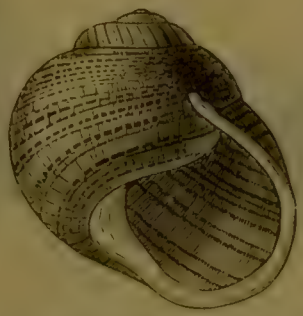


Fig. 197.—Helix undulata (Ferussac).

Fig. 198.—Helix translucida (Linnæus).

Helex pisana, with *H. aspersa* and *melastoma*, are preferred. At Bonifacio, *Helix aspersa*, *H. vermiculata*, and, more rarely, *H. rhodostoma;* and in other localities the smaller species and young individuals of the larger kinds are employed for feeding poultry.

Figs. 199 and 200.—Helix Waltoni (Reeve).

Certain species are also employed for feeding ducks. Thus, in the neighbourhood of Montpellier, ducks are fed upon *Helix variabilis* and *H. rhodostoma*. Some fishes, especially the young salmon, are very partial to the flesh of snails.

This important genus is very numerous in species, which are distributed in groups according to the form of the shell; that is,

whether it be globulous, as in Fig. 196, tun-bottomed, as in Fig. 197, plain or biform, as in Fig. 198, or truncated, as in Figs. 199 and 200. These figures will give the reader some idea of the multiplied and elegant forms which the shells of the genus *Helix* sometimes assume.

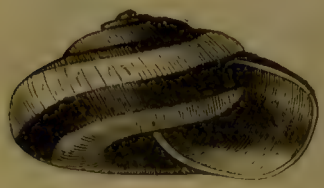


Fig. 201.—Helix citrina (Linnæus).

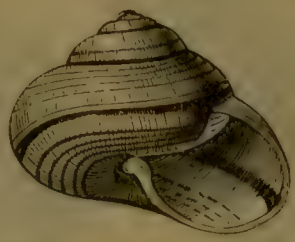


Fig. 202.—Helix Stuartia (Sowerby).

In connection with the genus *Helix* we shall note some kindred genera which our space only permits us to name. Such is the genus *Bulimus*, the European species of which are numerous; some of them

Figs. 203 and 204.—Bulimus sultanus (Lamarck).

very small, others of medium size; of these *Bulimus sultanus* (Figs. 203 and 204). In Figs. 205 and 206, the Berry Pupa (*Pupa uva*), as an example of another genus, is represented.

Yet another typical form may be noted, which is found abundantly amid the grass and in shrubs near brooks round Paris and elsewhere. It is *Succinea putris*, presenting a small, thin, diaphanous

shell of a pale amber yellow, marked with close and very fine longitudinal stripes (Fig. 207). The *Achatina zebra* of Chemnitz is a great

Figs. 205 and 206.—Pupa uva.

snail, which devours shrubs and trees in Madagascar (Fig. 208). Finally, *Vitrina*, the shell of which is very small and very thin in

Fig. 207.—Succinea putris (Linnæus).

Fig. 208.—Achatina zebra (Chemnitz).

Fig. 209.—Vitrina fasciata (Ed. and Soul).

some species—so small, indeed, in *Vitrina fasciata* (Fig. 209), that the animal cannot fully enter the shell—occupies a point of transition between *Helix* and *Limax*.

CHAPTER XVI.

Prosobranchiate Gasteropods.

In the Prosobranchiate division of the Gasteropods the branchiæ or gills are composed of numerous leaflets cut like the teeth of a comb, and attached, by one or many lines, to the upper part of the respiratory cavity. They constitute the most numerous order of Cephalous Molluscs, comprehending nearly all the univalve spiral shells, and many others which are simply conical. They inhabit the sea, rivers, and lakes, and are of all sizes. The most remarkable genera which we shall describe belong to the family *Trochoïdæ* and *Buccinoïdæ*.

This, the fourth order of Gasteropods, Prosobranchiata, includes the Pectinibranchiata and three other orders of Cuvier; in it the sexes are distinct, the branchiæ pectinated or plume-like, situated (*proson*) in advance of the heart, and the mantle forms a vaulted chamber over the back of the head. It is divided into two sections and twenty-one families. The first section, *Holostomata*, contains the sea-snails, where the margin of the aperture of the shell is entire. The muzzle is short, non-retractile, and they are mostly phytophagous. The second section contains the carnivorous Gasteropods. The aperture of the shell is notched or produced in front; animals with a retractile proboscis. Unlike the first section, the species are all marine.

The first family is that of the *Chitonidæ*. The *Chitons* are very singular creatures, destitute of eyes and of tentacles; they bear upon their back in place of a shell a cuirass composed of imbricated and movable scales. They have the power of elongating and contracting themselves like the snails. They roll themselves up into a ball like the woodlouse. They adhere with great force to the rocks, preferring those places most exposed to the beating waves. *Chiton magnificus* (Fig. 210) is widely distributed.

The second family, *Dentaliadæ*, supplies the curious genus *Dentalium*, or tooth shell.

The *Patellidæ*, or Limpets, constitute the third and a very numerous family, distinguished at once by the form and structure of

the animal and by that of the shell. Linnæus called it Patella, *i.e.*, a deep dish or knee-cap.

The shells of the Patellidæ are univalve, oval, or circular, non-spiral, but terminating in an elliptic cone, concave and simple beneath, non-pierced at the summit, entire and inclined anteriorly. They are smooth, or ornamented on the sides with ridges radiating from the summit, and often covered with scales; the edges are frequently dentate. The colours are very varied. The interior is very smooth, and remarkable for the brilliancy and lustre of its tints.

The head of the animal is furnished with two pointed tentacles or horns, having an eye at the external base of each. The body is oval and nearly circular, conical, or depressed. The foot is in the form of a thick fleshy disc. Certain lamellar branchiæ are arranged in series all round the body.

Fig. 210.
Chiton magnificus
(Deshayes).

The limpets dwell upon the sea-shore, in the parts alternately covered and uncovered by the waves. They are almost always attached to rocks, or other submerged bodies, to which they adhere with great tenacity. If the common limpet (*Patella vulgata*) is alarmed before any attempt is made to dislodge it, no human force, pulling in a direct line, can remove it, and it can sustain without being crushed a weight of many pounds. It holds on by the great quantity of vertical fibres in its foot, which in raising the median part forms in the centre a sort of sucker. It is the celebrated experiment of the Magdeburg cups which these little molluscs realise by their vital action.

These animals bury themselves in the chalky rocks to the depth of two or three lines; when they are dispersed, they are observed constantly to return to the same place. Their movements are, besides, extremely slow, the advance of the limpet being only perceived by watching the slow upheaval of the shell above the plane of its position. It is supposed, from the mouth being armed on its upper edge with a large semi-lunar, horny, cutting tooth, and in its lower part from having a tongue furnished with horny hooks, and from their inhabiting in great numbers places covered with marine plants, that their food is chiefly vegetable.

The poorer inhabitants of the coast eat limpets when they have nothing else, but their flesh is singularly coriaceous and indigestible.

They are found in every sea; but are, however, found to be

larger as well as more numerous and much richer in colour in equatorial seas, and especially in the southern hemisphere, than in European seas. They attain, in fact, their maximum of develop-

Fig. 211.—Patella cærulea (Lamarck).

Fig. 212.—Patella umbella (Gmel.)

ment there; for in the Straits of Magellan species are found as large as a slop-basin, which the natives use for culinary purposes.

The common limpet is thick, solid, oval, and nearly circular, generally conical, and covered with a great number of very fine

Fig. 213. Patella granatina (Linnæus).

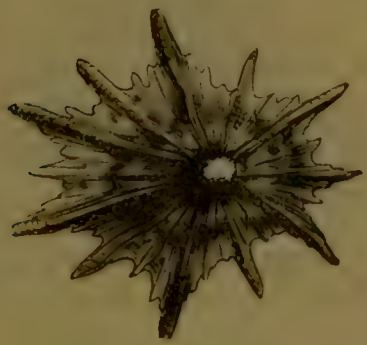
Fig. 214.—Patella barbata (Lamarck).

stripes. Its colour is of a greenish grey, uniform above, and of a greenish yellow inside. It is abundant in the Channel and on Atlantic coasts.

The blue limpet, *Patella cærulea* (Fig. 211), from St. Helena, has an oval shell, broadest behind, moderately thick, depressed,

flattened, covered with angular wrinkles, and dentate on the edge. It is of a spotted green outside and of a fine glossy blue within.

Other very elegant species are *Patella umbella* (Fig. 212), from the African coast; *Patella granatina* (Fig. 213), the ruby-eyed limpet from the Antilles; *Patella barbata*, the bearded limpet



Figs. 215 and 216.—Patella longicosta (Lamarck).

(Fig. 214); and the long spined Limpet, *Patella longicosta* (Figs. 215 and 216).

The fourth family, *Calyptræidæ*, of which the genera *Pileopsis* and *Calyptræa* may serve as a type, was classed by the older conchologists with *Patellidæ*. *Pileopsis hungaricus*, the Hungarian bonnet shell, is rather abundant on some parts of the British coast.

The fifth family, *Fissurellidæ*, contains the genera *Parmophorus*, the duck's-bill limpet of Australia, and *Fissurella*, the key-hole limpet, which is remarkable for the opening of the apex of the shell.

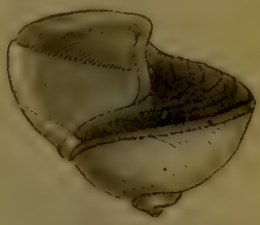


Fig. 217.
Ianthina communis
(Lamarck).

The sixth family, *Haliotidæ*, contains *Ianthina*, *Scissurella*, and *Haliotis*.

The attention of naturalists has long been directed to a curious mollusc known under the name of *Ianthina communis* (Fig. 217); its body is globular, and it presents an opening in front without contracting itself in order to form the head, which is long and trumpet-shaped, terminating in a large buccal opening, furnished with horny plates, and covered with little hooks; and two conical tentacles, slightly contracted, but very distinct, each bearing at their external base a long peduncle. The foot is short, oval, divided into two parts: the anterior, concave and cup-shaped; the posterior, flat and

fleshy. It is this foot, which bears a vesiculous mass like foam, which gives its peculiar character to the pretty mollusc. The mass consists of a great number of small eggs, which help to keep the animal on the surface of the water. The shell is light, transparent, violet-coloured, and very much resembles the shell of the Helix. The Ianthina inhabit the deep sea, and often form bands of very great extent. Messrs. Quoy and Gaimard have seen legions of Ianthina driven by the current. They have sailed during many days through these wandering tribes of molluscs, which would be the sport of every gale if they could not, by drawing their heads within their shells and contracting themselves, diminish their volume and increase their weight at will, so as to sink quietly to the bottom of the water till the tempest was over. The *Ianthina communis* possesses a liquid of a dark violet colour, which is believed by many naturalists to have been one of the purple dyes known to the ancients, if not the purple of Tyre: it is very common in the Mediterranean, and in all the oceans.

Haliotis tuberculata, the ear-shell, is remarkable for its brilliant colours, and for a line of singular perforations in many of the species.

The seventh family, *Turbinidæ*, contains *Trochus*, *Turbo*, *Rotella*, *Monodonta*, and *Delphinula*.

The species o. the genus *Trochus* are found in all seas, and near to the shore in the clefts of rocks, especially in places where sea-weeds grow luxuriantly. Some of these thick, cone-shaped shells are extremely beautiful, being richly nacred inside, and often remarkable for the beauty and diversity of colour they exhibit. Generally smooth, the principal spiral is, nevertheless, sometimes edged with a series of regular spines. The form is conical, the spiral more or less raised, broad and angular at the base; the opening entire, depressed transversely, and the edge disunited in the upper part.

The animal which inhabits this shell is also spiral; its head is furnished with two conical tentacles, having at their base eyes borne on a peduncle; its foot is short, round at its two extremities, edged or fringed round its circumference, and furnished with a horny operculum, circular and regularly spiral.

The family consists of many genera or sub-genera. Among the species of Trochus, properly so called, we may notice *Trochus niloticus* (Fig. 218), *T. virgatus* (Fig. 219), *T. inermis* (Fig. 220), and *T. Cookii* (Fig. 221), *T. imbricatus* (Fig. 222).

The species of the genus *Turbo* are very generally diffused, being found on every shore, where they cling to rocks beaten by the waves.

About fifty species are known, some of them large shells, others very

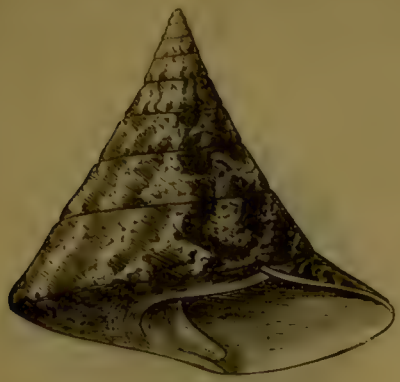


Fig. 218.—Trochus niloticus (Linnæus).

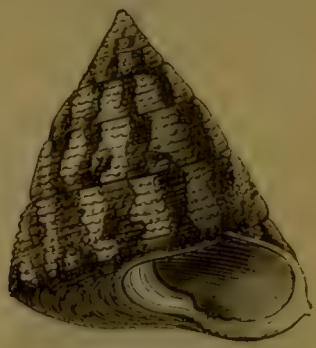


Fig. 219.—Trochus virgatus (Gmel.

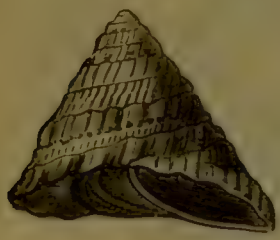


Fig. 220.—Trochus inermis (Gmel.)

Fig. 221.—Trochus Cookii (Chemnitz).

Fig. 222.—Trochus imbricatus (Gmel.)

Fig. 223.—Phorus conchyliophorus (Borfu).

small. *Turbo margaritaceus* (Fig. 224) is a large, thick, and weighty shell, round-bellied, and deeply furrowed; in colour it is yellow, or

rust-coloured, marked by square brown spots. *Turbo argyrostomus*, the Silver-mouthed Turbo (Fig. 225), is still larger, with protecting spines on the top of its larger spiral. *Turbo marmoratus* (Linnæus),

Fig. 224.—Turbo margaritaceus (Linnæus).

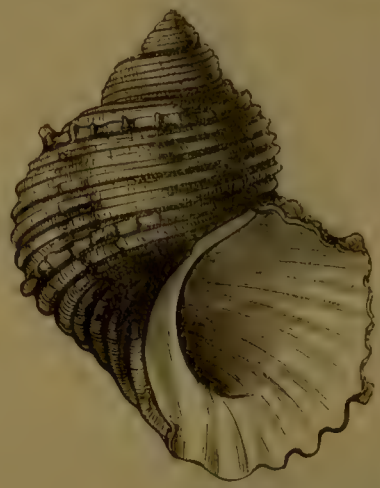


Fig. 225.—Turbo argyrostomus (Linnæus).

Fig. 226.—Turbo marmoratus (Linnæus).

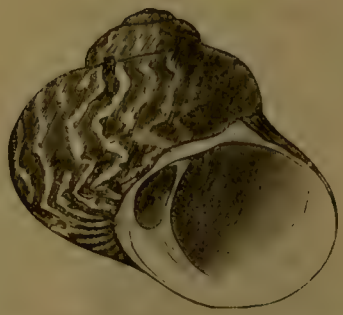


Fig. 227.—Turbo undulatus (Chemnitz).

the Marbled Turbo (Fig. 226), is the largest shell in the group. It is marbled green, white, and brown, outside, and superbly nacred within. The Gold-mouthed Turbo is so named from its nacre being of a rich golden yellow. The Wavy Turbo (*T. undulatus*, Fig. 227), commonly

known as the Australian Serpent's Skin. The shell is white, ornamented with longitudinal waving flexible lines of spots of green, or greenish-violet. *Turbo imperialis* (Fig. 228), from the Chinese seas, is green without, and brilliantly nacred within; it is commonly known as the paroquet shell.

The genus *Turbo* is found in the North seas, in the Channel, and on the Atlantic coast. The animal is eaten in nearly all the seaports of the Channel.

Rotella Zealandica, from the Indian Ocean, whose shell, represented

Fig. 228.—Turbo imperialis (Gmel.).

Fig. 229.
Rotella Zealandica.

Fig. 230.—Monodonta australis (Lamarck).

in Fig. 229, presents the most lively colours, forms one of a genus by no means numerous in species. This New Zealand species has the spiral turns of its shell sculptured in descending furrows, and studded with imbricated scales, which form a projecting edging round its margin, and give it a radiating form. This species is of a violet brown above and white below.

Near to the genera *Trochus* and *Turbo* in this system comes the genus *Monodonta*.

The *Monodonta* are elegantly-marked shells, belonging to the seas of warm countries. *M. Australis* (Fig. 230) is a native of the Australian seas. *M. labia* (Fig. 231) is a small brown shell, with

white spots, which is very common on the shores of the Mediterranean.

The eighth family is *Neritidæ*, of which we may give as typical genera, *Neritina*, *Navicella*, and *Nerita*. The species of *Nerita* are numerous and pretty, and are mostly marine.

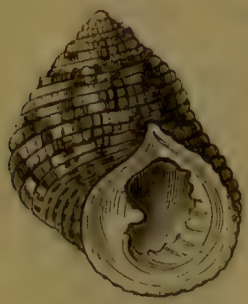


Fig. 231.—Monodonta labia (Lamarck).

Fig. 232.—Delphinula sphærula (Kiener).

The ninth family, *Turbinidæ*, has among its more important genera those of *Turbo*, *Phasianella*, *Trochus*, *Delphinula*, and *Imperator*. Of *Delphinula* only about seventy living species are known. They are

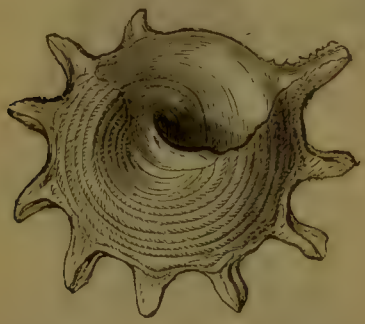


Fig. 233.—Imperator stella (Lamarck).

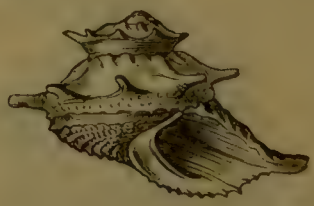


Fig. 234.—Trochus stellaris (Gmel).

mostly natives of the Indian Ocean, and are remarkable for their numerous spines and the asperity of their shells (Fig. 232). Of the genus *Imperator* we may instance the Spurred Trochus, *Imperator stella*, which is studded with radiating spines (Fig. 233), *Imperator stellaris* (Fig. 234), they are natives of the Australian seas, and *Imperator imperialis*, commonly called the Royal Spur.

Our tenth family, *Littorinidæ*, contains the genera *Solarium*,

Littorina, periwinkles, and *Phorus*, as an example of this latter genus, we have *P. Conchyliophorus* (Fig. 223, page 443).

The Staircase-shell (*Solarium perspectivum*), is recognised by its deep umbilicus, wide and funnel-shaped, in the interior of which may be seen the little crenated teeth which follow the edge of every turn of the spiral up to the top. In most collections of these pretty shells we find this Staircase-shell (*Solarium perspectivum*) of Lamarck, from the Indian Ocean (Figs. 235, 236), the diameter of which is sometimes two inches and a half. The Australian Sun-dial (*S. variegatum*, Linnæus, Fig. 237) is another species frequently seen in collections; it is as much variegated above as below, of a white and rusty brown

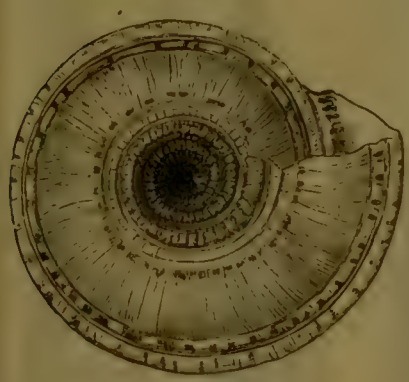


Fig. 235.—Solarium perspectivum.

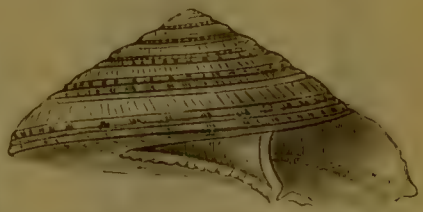


Fig. 236.—Solarium perspectivum.

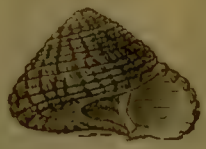


Fig. 237.—Solarium variegatum.

Another species, the minute, trellised Sun-dial, which is only ten lines in diameter, comes from the coast of Tranquebar.

The eleventh family, *Turritellidæ*, has, as typical genera, *Vermetus*, *Scalaria*, and *Turritella*, which last is a genus with a great number of species, many of which are found in every sea. All these shells, as their name indicates, represent a winding pyramid, terminating in a sharp point, some of them having fluted spirals, others rounded, angular, or flat, and some of them elegantly pencilled. Figs. 238 to 242 represent some of the species of the genus.

The twelfth family, *Melaniadæ*, contains the fresh-water genera, *Paludomus* and *Melania*.

The thirteenth family, *Cerithiadæ*, contains the genera *Potamides*, *Aporrhais*, and *Cerithium*.

The species of the genus *Cerithium* are marine, and are chiefly found in muddy bottoms, and more frequently at the mouths of rivers,

but rarely beyond the point to which the tide reaches. The genus is numerous in species, of which we figure *Cerithium fasciatum* (Fig. 243) and *Cerithium aluco* (Fig. 244). The Giant Cerithium, *Cerithium giganteum* (Fig. 245), is the living analogue of a magnificent fossil species belonging to the Tertiary formation. The single known example of this species belongs to the Delessert Museum at Paris. A manuscript note by Lamarck, attached to this specimen, relates

Fig. 238.—Turritella replicata (Linnæus).

Fig. 239.—Turritella angulata (Sowerby).

Fig. 240.—Turritella sanguinea (Reeve).

Fig. 241.—Turritella goniostoma.

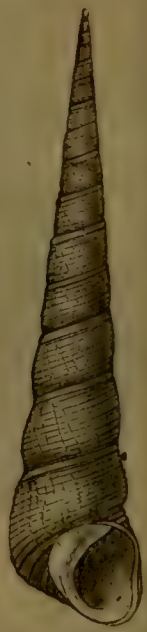


Fig. 242.—Turritella terebellata (Lamarck).

that this shell was first brought to Dunkirk in 1810 by an Englishman, one of the crew of an English ship; he had drawn it up from the bottom of the sea with the sounding-lead from a bed of rocks off the coast of Australia.

The fourteenth family, *Pyramidellidæ*, contains the genera *Eulima*, *Stylifer*, *Chemnitzia*, and *Pyramidella*.

The fifteenth family, *Naticidæ*, contains *Velutina*, *Sigaretus*, *Lamellaria*, and *Natica;* species of this last being found in most seas.

The second section of the *Prosobranchiata* is termed SIPHONOSTOMATA, and is characterised by the shell being spiral and usually

imperforate, the animal of which has sometimes a horny operculum, and is furnished with a retractile proboscis; the margin of the mantle

Fig. 243.—Cerithium fasciatum (Brug.).

Fig. 244.—Cerithium aluco.

Fig. 245.—Cerithium giganteum (Lamarck).

is prolonged into a siphon. The species are all marine, and are carnivorous.

The first family is the *Cypræidæ*, containing the well-known genera, *Cypræa* and *Ovulum*.

The Cowries (*Cypræa*), have brilliant, smooth, and polished, oval-shaped, or oblong convex shells, with edges rolling inwards, and longitudinal openings, narrow, arched, dentate on both edges, and notched at the extremities. The spiral, placed quite posteriorly, is very small, and often hidden by a calcareous bed of a vitreous appearance.

It is now known that the form and colouring of the shells vary very considerably, according to the age of the animal; so much so, indeed, that the same species examined at various stages of its growth

Adults.

Young.

Fig. 246.—Cypræa Scottii (Broderip).

Fig. 247.—Cypræa Scottii (Broderip).

Fig. 248.—Cypræa (Broderip).

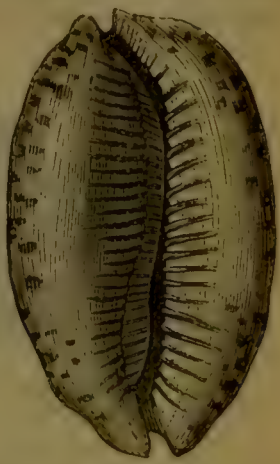
would almost seem to belong to species and even to genera essentially different.

The young cowries are thin, conical, elongated, with a conspicuous spiral and large openings. The right edge soon becomes thicker, and folds itself inwardly; the opening is narrowed; finally, the spire is unfolded in successive folds from the right edge, and by successive deposits of the vitreous matter we have spoken of the opening is gradually contracted, its extremities hollowed out, its edges disconnected, and the shell, until now only shaded in pale tints, assumes its most brilliant colours, which are disposed in bands or spots, as exhibited in Figs. 246 and 247, which are the adult shells, and Fig. 248, which is the young shell, of *Cypræa Scottii*.

The animal which inhabits this shell is elongated, and is provided

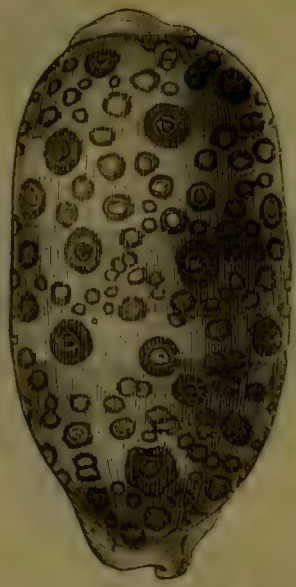
with a well-developed mantle, furnished on the inside with a band of tentacular filaments; it is able to fold itself over its shell in such a

Fig. 249.—Cypræa mappa.



Figs. 250 and 251.—Cypræa histrio (Linn.).

Fig. 252.—Cypræa tigris (Linn.).



Figs. 253 and 254.—Cypræa argus (Linn.).

manner as to envelop it all round. The head is provided with two very long conical tentacles, each having a very large eye. The foot is oval, elongate, and without operculum, and is well represented in

Cypræa tigris (Fig. 255). The cowries are found at a little distance from the shore, generally in clefts of the rocky bottoms; but sometimes they bury themselves in the sand. They are timid, shun the light, and only leave their retreats to creep about in search of food,

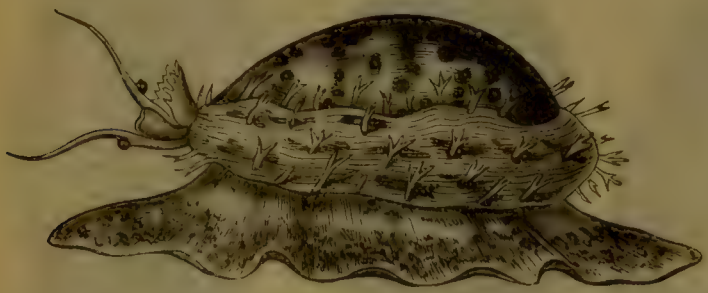


Fig. 255.—Cypræa tigris (Linnæus).

Fig. 256.—Cypræa coccinella (Lamarck).

which appears to be exclusively animal. These magnificent molluscs are natives of every sea. One small species lives in the British Channel; another and much larger species is found in the Adriatic; but the Indian Ocean is the home of the largest and finest species of these shells.

As objects of curiosity and ornament these shells have been much

Figs. 257 and 258.—Cypræa undata (Lamarck).

Figs. 259 and 260.—Cypræa zigzag (Linnæus).

in request in all ages. The inhabitants of the Asiatic coast make bracelets, collars, amulets, and head-dresses of them, and use them to ornament boxes and harness. In New Zealand and the Fijis the chiefs carry a rare and choice species (*Cypræa aurantium*), suspended from the neck, as a badge of their rank or sign of distinction. The species are, indeed, extremely numerous, and we can only find room for very brief descriptions of a few of the best known among them.

The Waving and Zigzag Cowries (*C. zigzag* and *C. undata*, are beautifully ornamented with waving and broken lines, as we see them in Figs. 257 to 260.

The Orange Cowrie (*C. aurantium*), of which we have spoken

Figs. 261 and 262.
Cypræa moneta (Linnæus).

Fig. 263.—Cypræa Madagascariensis (Gmel.).
(1 and 2.)

Fig. 264.—Cypræa capensis (Gray).

Figs. 265 and 266.—Cypræa testudinaria (Linnæus).

above, is nearly globular, of a uniform orange colour above, and white below; the teeth of the opening are of a bright orange. The shell is rare, and much sought after.

The Money Cowrie, *Cypræa moneta* (Figs. 261 and 262), is a

little oval shell, depressed, flat below, with very thick edges and slightly waving. It is of a uniform yellowish-white colour, sometimes citron-yellow above and white below. There are usually twelve teeth in the outer lip of the adult shell. It comes from the Indian Ocean, the Maldivian Isles, and the Atlantic Ocean.

Figs. 267 and 268.
Cypræa nucleus (Linnæus).

This shell, so common in collections, is gathered by the women on the shore of the Maldivian Isles, three days after the full moons and before the new moons; it is afterwards transported to Bengal, to India, and Africa, where it is used by the negroes and other natives as money.

The Madagascar Cowrie, *Cypræa Madagascariensis* (Fig. 263), and the Granular Cowrie, *Cypræa nucleus* (Figs. 267 and 268), are beautifully marked species, having the general appearance of being mammillated all over.

Fig. 269.
Cypræa pantherina (Sol.).

The species most abundant in the British seas is the little *Cypræa* (*Trivia*) *europæa*, already mentioned; it is very small, oval, tun-bellied, the opening dilated in front with smooth transverse stripes of greyish, tawny, or rose-colour, with or without spots.

Cypræa mappa (Fig. 249) is oval-shaped, swelling below its sides, well-rounded, ornamented with small white spots below, with a dorsal branching line above; the interior is violet colour, with thirty-six teeth on one side, and forty-two on the other. It is met with in the Indian Ocean.

The Harlequin Cowrie, *Cypræa histrio* (Figs. 250 and 251), from the coast of Madagascar, is ornamented with white spots very closely arranged, and much circumscribed above, with black spots upon the sides. The under side is violet.

A very fine species, which is very common in collections, is found in the Indian Ocean, from Madagascar to the Moluccas—the Tiger Cowrie, *Cypræa tigris*, already figured with the animal. The shell (Fig. 252) is large, oval, tun-bellied, thick, and convex, of a bluish

white, ornamented with numerous broad, black, round spots, much scattered, and a straight dorsal line, brown above, and very white

Fig. 270.—Natural size of Ovulum oviformis (Lamarck).

below. It has generally twenty-three teeth on each edge, quite white. Somewhat resembling the Tiger Cowrie is the *Cypræa pantherina* (Fig. 269), which is perhaps a variety of the same species. Another remarkable species is *Cypræ argus*, as represented in Figs. 253 and 254.

Fig. 271. Ovulum cornea (Lamarck).

The genus *Ovulum*, so called from their egg-shaped form, occupy a place next to the Cowries in some systems. The shell is highly polished, white or rose-coloured, oblong or oval, convex, attenuate, and acuminate at the extremities without apparent spire, the edges milled within the long, narrow, and curved opening, with teeth upon the left edge, and with a few ripples on the right edge. The species of Ovulum are inhabitants of the Indian Ocean and Chinese Seas. Some few species, however, belong to the Mediterranean and the Black Sea. The three species represented in Figs. 270, 271, and 272, present very singular contrasts of form and size.

The second family, *Volutidæ*, contains the genera *Cymba*, *Marginella*, *Mitra*, and *Voluta*.

The Mitres are so called from their resemblance to the bishop's

mitre. They are chiefly natives of warm climates, such as the Indian Ocean, the Australian Seas, and the Moluccas. The shells of the

Fig. 272.- Ovulum volva (Linnæus).

Mitres are long, slender, and spiral, the spire ending in a point at the summit: the opening is small, narrow, and triangular, and notched in front. The animal has a very long proboscis; it emits a purple liquid, having a nauseous odour when irritated. The eyes are placed on the tentacles or at their base. *Mitra episcopalis* (Fig. 273), from the Indian Ocean, is white, ornamented with square spots of a fine red, and capable of high polish.

Fig. 273.
Mitra episcopalis
(Lamarck).

Fig. 274.
Mitra papalis
(Lamarck).

Mitra papalis (Fig. 274) has dentiform folds round the opening, which also crown each turn of the spiral; the spots are smaller, and much more numerous and varied in form than those of *M. episcopalis*.

In the genus *Voluta* the shell is oval, more or less tun-bellied—the spire is short, slightly mammillate, the opening large, the edges notched, without channel; the columellar edge is lightly excavated and arranged in oblique folds. The right edge is arched, thick, or cutting, according to the species.

The animal has a large head, provided with two tentacles. The mouth terminates in a thick trunk furnished with hooked teeth. The foot is very large, furrowed in front, and projecting from all parts of

I.—Voluta undulata (Lamarck).

II.—Voluta cymbium (Linn.).

III.—Voluta Delessertii (Petit).

IV.—Voluta musica (Linn.).

V.—Voluta imperialis (Lamarck).

VI.—Voluta scapha (Gmel.).

VII.—Voluta vexillum (Chem.).

XX.—Voluta.

the shell, but without operculum. The Volutes live on the sands near the shore; sometimes they are found high and dry, left by the retreating tide. Their shells, of various forms, are ornamented with the most lively colours, the surface covered with irregular lines, the tint of which is generally in strong contrast with that of the ground.

Among the more remarkable species illustrated in PLATE XX., we may note: Fig. I., *Voluta undulata:* Fig. II., *Voluta cymbium;* Fig. III., *Voluta Delessertii;* Fig. IV., *Voluta musica;* Fig. V., *Voluta imperialis;* Fig. VI., *Voluta scapha;* and Fig. VII., *Voluta vexillum.*

The third family, *Conidæ*, contains *Pleurotoma* and *Conus.*

The genus *Conus* is especially rich in species, as well as numerous in individuals. The shells are much sought after by collectors, many being rare, and so command high prices. Those belonging to this group present a very remarkable uniformity of shape, at the same time that the colours are very fine, and much varied in design. The shell is thick, solid, inversely conical, wreathing spirally from the base to the apex, the spire being generally short, the last turn constituting alone the greater part of the surface of the shell. The opening extends nearly along its whole length, occupying all the height of the last whorl. It is always narrow, its edges quite parallel; the columella presents neither fold nor curvature; the right edge is plain, sharp, and thin, detached from the front of the last spiral by a sloping hollow, more or less deep.

The animal creeps upon a foot, elongated, narrow, truncate in front, furnished behind with a horny rudimentary operculum, altogether insufficient to cover the opening. The head, which is large, is elongated into a little snout, or muzzle, at the base of which rises on either side a conical tentacle, having an exterior eye upon its anterior extremity. At the extremity of the muzzle is the mouth, which is armed within with numerous horny teeth in pairs, elongate or hastate. A cylindrical syphon, reversing itself in the shell, serves the purpose of carrying water to the branchiæ or gills. The shells inhabit the seas of warm countries, especially those lying between the Tropics, where they affect sandy coasts, with a depth of ten to twelve fathoms of water.

Among the species bearing a spiral crown, we may mention the rare *Conus cedo-nulli*, of which several varieties are known, which come from the South American Seas and the Antilles.

Conus hebraica, from the shores of Asia, Africa, aud America, is a common species. It is white with black spots, which are nearly square, arranged in transverse bands.

In PLATE XXI. we have represented some interesting species. *Conus imperialis* (Fig. I.) is a fine species, of white colour, with bands of a greenish yellow or tawny colour, ornamented with transverse, cord-like, articulated lines of white and brown. One of the largest species is *Conus geographus* (Fig. II.), which sometimes attains the length of six or seven inches; it is shaded white and brown.

Among the non-crowned species, we have represented in Fig. III. *Conus tessellatus*, common in the Indian Ocean. Its anterior part is violet in the interior. The spots with which it is surrounded are of a fine red or scarlet, or, in short, a red lead colour upon a white ground.

Conus ammiralis, of which three varieties, Figs. IV., V., and VI., are natives of the seas which bathe the Moluccas; they are beautifully marked varieties, of a brownish citron colour, marked with white spots nearly triangular, with tawny bands painted in very fine tracery. This species has been, and is still, much sought after by collectors, and presents many varieties besides those represented.

Among the shells, which seem almost ready to become cylindrical, may be noted *Conus nobilis* (Fig. VII.), a rare shell of yellowish colour approaching citron, ornamented with white spots. The golden drop, *Conus textile* (Fig. VIII.), is yellow in colour, ornamented with waving longitudinal lines of brown, and white corded spots edged with tawny colour. The glory of the sea, *Conus gloria maris* (Fig. IX.), is white in colour, banded with orange, and reticulated with numerous triangular white spots edged with brown. This is a native of the East Indies, and one of the most beautiful shells of the whole group.

The fourth family, *Buccinidæ*, contains numerous genera, as examples of which we may instance *Oliva*, *Harpa*, *Cassis*, *Purpura*, *Nassa*, *Terebra*, *Eburna*, and *Buccinum*.

The genus *Oliva* is so named from its resemblance in form to the olive. Its nearly cylindrical shell is slightly spiral, polished, and brilliant, as in the Cowries; its opening is still long and narrow, strongly notched in front, its edge columellar, swollen anteriorly into a kind of cushion, and striped obliquely in all its length.

These Molluscs belong to the seas of warm countries, where they frequent the sandy bottoms and clear waters. They creep about with much agility, reversing themselves quickly when they have been overturned; they live upon other animals, and are flesh-eaters. They are, in fact, taken at the Isle of Tranu by using flesh as bait. The colours of the shell are very varied, and sometimes fantastically streaked. *Oliva erythrostoma* (Fig. 275) is ornamented externally

Conus imperialis (Linn.).

II.—Conus geographus (Linn.).

III.—Conus tessellatus (Born.).

IV., V.—Conus ammiralis (Linn.).

VI.—Conus ammiralis (Linn.).

I.—Conus nobilis (Linn.).

IX.—Conus gloria maris (Chemn.).

VIII.—Conus textile (Linn.).

with flexual lines of a yellowish brown, with two brown bands, combined with the fine yellowish tint of gold colour within. *Oliva porphyria*, from the Brazil coast (Fig. 276), presents lines of a reddish brown, regularly interlaced with spotted large brown marks, upon a flesh-coloured ground. *Oliva irisans* (Fig. 277) is painted in zigzag lines, close and brown, edged with orange-yellow, and with two zones of darker brown, and reticulated. *Oliva Peruviana* (Fig. 278) is furrowed with regularly spaced bands.

In the genus *Cassis* the shell is oval, convex, and the spire is

Fig. 275. Oliva erythrostoma (Lamarck).

Fig. 276. Oliva porphyria (Linnæus).

Fig. 277. Oliva irisans (Lamarck).

Fig. 278. Oliva Peruviana (Lamarck).

not of considerable height. The longitudinal opening is narrow, terminating in front in a short channel, which becomes suddenly erect towards the back of the shell, as in *Cassis glauca* (Fig. 279), a fine shell from the Moluccas. The columella is folded or toothed transversely, as in *Cassis rufa*, Fig. 280; the right edge thick, furnished with a sort of pad externally, and dentate within. This shell is from the Indian Ocean, and is of a fine purple colour, varied with black above; the edges of the opening being of a coral red colour, the teeth alone being white.

The head of the animal is large and thick, furnished with two conical elongated tentacles, at the base of which are the eyes. The mantle is ranged outside the shell, falling back upon the edges of the opening, and terminating at its anterior extremity in a long cylindrical channel, cloven in front, and passing by a hollow at the base into the

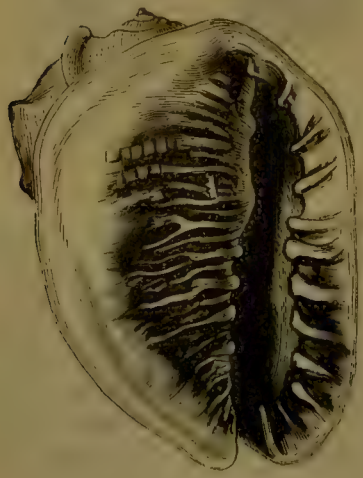
branchial cavity. The foot is large, and furnished with a horny operculum.

These animals keep near the shore, in shallow water. They walk

Fig. 279.—Cassis glauca (Linnæus).

Fig. 280.—Cassis rufa (Linnæus).

Fig. 281.—Cassis canaliculat (Brugières).



Figs. 282 and 283.—Cassis Madagascariensis (Lamarck).

slowly, and often sink themselves into the sand, where they pre upon small bivalves. There are not very many species; but spec mens from the Indian Ocean are often large and beautifully marke

The shells of the less marked species are frequently used in India as lime for making mortar, under the name of Chunam.

Our space only permits us to mention, among the more curious species, *Cassis canaliculata* (Fig. 281), two varieties of *Cassis Madagascariensis* (Figs. 282 and 283), and the curious *Cassis Zebra* (Lam.), or Zebra-marked Casque (Fig. 284).

The Purpuras have a classical name and history, having furnished the Greeks and Romans with the brilliant purple colouring matter which was reserved for the mantles of patricians and princes. The genus Purpura is characterised as possessing an oval shell, thick pointed, with short conical spiral, as in *Purpura lapillus* (Fig. 285). In some it is tubercular or angular, the last turn of the spiral being larger than all the others put together. The opening is dilated, terminating at its lower extremity in an oblique notch. The columellar edge is smooth, often terminating in a point; the right edge often digitate, thick internally, and folded or rippled.

The animal presents a large head, furnished with two swollen conical tentacles, close together, and bearing an eye towards the middle of their external side. Its foot is large, bilobate in front, with a semicircular horny operculum.

The species of Purpura inhabit the clefts of rocks in marine regions covered with algæ. On occasions they bury themselves in the sand. They creep about by the help of their foot in pursuit of bivalves. They are found in all seas; but the larger species and greatest numbers come from warm regions, more especially from the West Indian and Australian seas.

The Purpura of the ancients was not, as is generally thought, a vermilion red, but rather a very deep violet, which at a later period came to have various shades of red. The secret of its preparation was only known to the Phœnicians, that being most esteemed which came from Tyre. Sir William Wilde has discovered on the eastern shores of the Mediterranean, near the ruins of Tyre, a certain number of circular excavations in the solid rock. In these excavations he found a great number of broken shells of *Murex trunculus*. He thinks it probable that they had been bruised in great masses by the Tyrian workmen, for the manufacture of the purple dye. Many shells of the same species are found actually living on the same coast at the present time.

Aristotle, in his writings, dwells upon their purple dye. He says that this dye is taken from two flesh-eating molluscs inhabiting the sea which washes the Phœnician coast. According to the description given by the celebrated Greek philosopher, one of these animals had

a very large shell, consisting of seven turns of the spire, studded with spines, and terminating in a strong beak; the other had a shell much smaller. Aristotle named the last animal *Buccinum*. It is thought that the last species is to be recognised in the *Purpura lapillus* (Fig. 285), which abounds in the Channel. Réaumur and Duhamel obtained, in fact, a purple colour from this species, which they applied to some stuffs, and found that it resisted the strongest lye. The genus *Murex* is supposed by some to have contained the species indicated by Aristotle.

Up to the present time, the production of the Tyrian purple remains

Fig. 284.—Cassis zebra (Lamarck).

Fig. 285.—Purpura lapillus.

Fig. 286.—Purpura patula.

a mystery. It was long thought this fine dye was furnished by the stomach and liver; but M. Lacaze-Duthiers has demonstrated that the organ which secretes it is found on the lower surface of the mantle, between the intestines and the respiratory organs, where it forms a sort of fascia, or small band. The colouring matter, as it is extracted from the animal, is yellowish; exposed to the light, it becomes golden yellow, then green, taking finally a fine violet tint. While these transformations are in progress a peculiarly pungent odour is disengaged, which strongly reminds one of that of assafœtida. That portion of the matter which has not passed into the violet tint is soluble in water; when it has taken that tint it becomes insoluble. The appearance of the colour seems provoked rather by the influence of the sun's rays than by the action of the air. The matter

ttains its final colour, in short, in proportion to the power of he sun's rays.

It is a question how far the colour evolved under the solar rays emains indelible. It is known that the contrary is the case with the olouring matter of the cochineal insect, which changes very quickly vhen exposed to the sun. It is probable that it was the remarkable esistance which this purple opposed to the rays of the sun which recommended it to the ancients. The patricians of Rome, and the rich itizens of Greece and Asia Minor, loved to watch the magical reflections of the sun on the glorious colour which ornamented their mantles.

Fig. 287.—Purpura consul.

Fig. 288.—Buccinum senticosum (Linnæus).

Fig. 289.—Buccinum undatum (Linnæus).

But to return to our humble shells. *Purpura lapillus* (Fig. 285) is a thick shell, oval, acute, with conical spire, generally of a faded or yellowish white, zoned with brown, and more or less spotted.

Purpura patula (Fig. 286) is very common in the Philippines, and is one of the handsomest species; its geographical distribution has been a subject of much inquiry.

Purpura consul (Fig. 287) is one of the large shells of this genus, and of a fine salmon colour, with brown bands and a corona of spines.

The genus *Buccinum* resembles that of *Purpura* in many respects. Its shell is oval or conical, much notched in front. The species inhabit every sea, especially those of Europe. The animal has a

small flat head, furnished with lateral tentacles or horns, bearing the eyes upon an external swelling, situated near their central length. We need only refer to Fig. 288, *Buccinum senticosum*, and *Buccinum undatum*, the well-known whelk of our markets (Fig. 289), for their general form.

The genus *Harpa* contains shells from the Indian Ocean, richly enamelled within, and ornamented externally with slightly oblique longitudinal stripes in gay colours, with finely-sculptured forms in the intervals; spire very small, and opening large. Among the more

Fig. 290.—Harpa ventricosa (Lamarck).

Fig. 291.—Harpa imperialis (Lamarck).

attractive species are *Harpa ventricosa* (Fig. 290), *Harpa imperialis* (Fig. 291), and *Harpa articularis* (Fig. 292).

The fifth family, *Muricidæ*, contains *Fusus*, *Pyrula*, *Triton*, and *Murex*.

The genus *Murex*, or Rock Shells, include a large number of species, all remarkable for their bright colours and somewhat fantastical and varied forms. They are found in all seas, but become larger and more branching in the seas of warm regions. The shell is oval, or rather oblong, the spire more or less elevated, its surface generally covered with rows of spines, or tubercular ramifications. The opening, which is oval, is prolonged in a straight canal, often of very considerable length, as in *Murex haustellum* (Fig. 293); the external edge is often smooth or rippled, the columellar edge sometimes callous.

The head of the animal is furnished with two horns or tentacles, with ocelli upon their external side, the mouth elongated in the form of a proboscis. The foot is large and round, and furnished with a horny operculum.

Among the species with long slender tube, covered with spines, one of the most notable is *Murex tenuispina* (Fig. 294), which is a native of the Indian Ocean and the Moluccas.

Fig. 292.—Harpa articularis (Lamarck).

Fig. 293.—Murex haustellum (Linnæus).

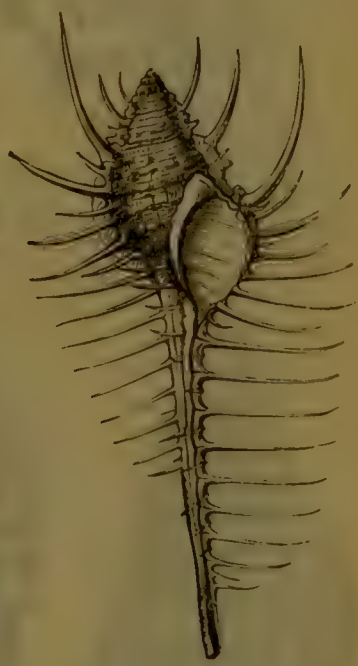


Fig. 294.—Murex tenuispina (Lamarck).

Among the strong-tubed species with long canal and no spines, from the same regions, is *Murex haustellum* (Fig. 293).

Among the short-tubed species, furnished with foliaceous and jagged fringes, is *Murex scorpio* (Fig. 295).

One more typical species may be noted, namely, *Murex erinaceus* (Fig. 296), which is found on all the coasts of Europe, and especially in the British Channel. Other species worthy of notice are found in the Mediterranean and Adriatic, some of them, according to Cuvier and de Blainville, species which furnished the true Tyrian purple of the ancients; but our space prevents us from dwelling on them.

Fig. 295.—Murex scorpi (Linnæus).

Fig. 296.—Murex erinaceus (Linnæus).

Fig. 297.—Triton variegatum (Lamarck).

Fig. 298.—Triton lotorium (Linnæus).

Fig. 299.—Triton anus (Lamarck).

The genus *Triton* is ranged beside the genus *Murex* in this system. The shell is irregularly covered with scattered swelling excrescences, not, as in *Murex*, in longitudinal rows, but scattered

all over the surface. About 100 species of Triton are known. They inhabit many seas, but more especially those of warm countries. *Triton variegatum*, commonly called the Marine Trumpet (Fig. 297),

Fig. 300.—Fusus proboscidiferus (Lamarck).

Fig. 301.—Fusus pagodus (Lesson).

Fig. 302.—Fusus colus.

is a very large shell, which even attains a length of sixteen inches; it is enamelled with great elegance in white, red, and tawny brown. It comes from the Indian Ocean, where the shells are very common. *Triton lotorium* (Fig. 298) is of a reddish brown externally and white within. The *Triton anus* (Fig. 299) is of a whitish colour, spotted with red.

The genus *Fusus* (or spindle-shells) is distinguished by the elegance of its form rather than by the brilliancy of its colours. The species are spindle-shaped, spire many-whorled, canal long, operculum egg-shaped. Among the more remarkable species may be noted *Fusus proboscidiferus* (Fig. 300), *Fusus pagodus* (Fig. 301), and *Fusus colus* (Fig. 302).

The sixth family is *Strombidæ*, of which we give as typical genera *Rostellaria*, *Pteroceras*, and *Strombus*. *Strombus* is a marine genus, belonging to equatorial seas, of whose habits and manners very little is known. It is probable that the species are long lived, for their shells, when found perfect, have acquired a very considerable thick-

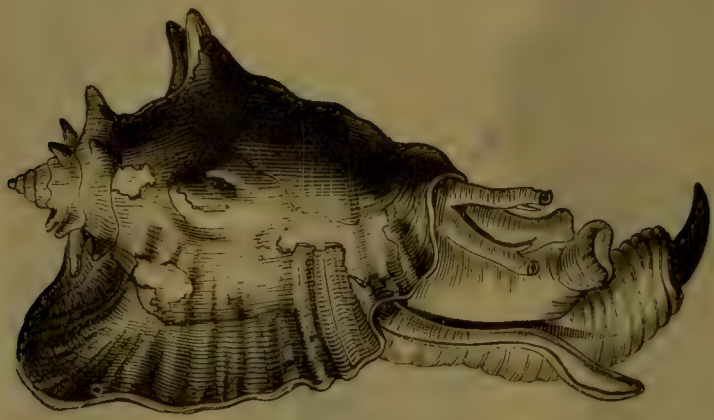


Fig. 303.—Strombus gigas (Linnæus), with the animal.

ness and weight. They are even found encrusted in the interior with numerous layers of soft earthy sediment, and covered externally with small corals and other marine productions. *Strombus gigas* is represented in Figs. 303 and 304.

Some species of *Strombus* attain great size, and are placed as ornaments in halls and dining-rooms. In some of them the opening is brilliantly shaded, and those are chiefly sought after to decorate grottoes in gardens, or for collections of shells, where, from their size, they necessarily occupy a prominent place.

These shells are rather ventricose, terminating at their base by a short canal, notched or truncated; the right edge gets dilated with age; simple on one wing, lobed or cuneated in the upper part, and presenting in its lower part a groove or cavity separated from the canal or from the notch at the base. But these shells are not merely

ornamental, for some of the streets of Vera Cruz are said to be paved with *Strombus gigas*.

The animal which inhabits this shell presents a distinct head, provided with a trunk or snout, and with two tentacles or horns, each bearing a large and vividly-coloured eye. The foot is compressed and divided into two portions, the posterior one, which is the longest, bearing a horny operculum. In the eagle-winged *Strombus*, represented in Figs. 303 and 304, these several peculiarities are well developed. This shell is large, turbinate, distended in the middle, with an acutely-

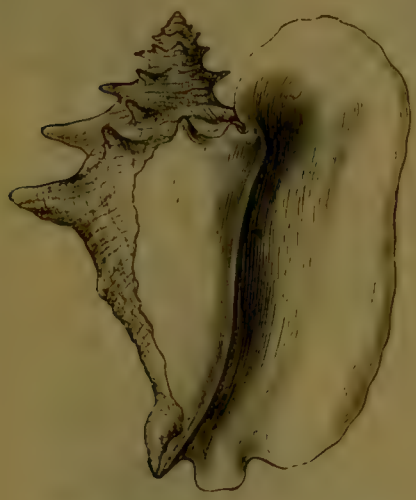


Fig. 304.—Shell of Strombus gigas.

Fig. 305.—Strombus gallus (Linn.).

pointed spire studded with conical tubercles, the right edge very broad, rounded off below. The opening is of a vivid rose purple fading into white. It is a native of the Antilles.

Strombus gallus, or the Angel-winged (Fig. 297), is veined with stripes of white and red, and comes from the coasts of Asia and America. *Strombus luhuanus* (Fig. 306) is fawn-coloured, marked with white, externally the right edge is red and striped, inside the columella is shaded purple and black.

Strombus cancellatus, the trellised Strombus (Fig. 307), is small in size, and white in colour. *Strombus thersites* is also represented in Fig. 308.

The genus *Pteroceras*, from πτερὸν, *wing*, and κέρας, *horn*, in many respects resembles the genus *Strombus*. The species are distinguished

Fig. 306.—Strombus luhuanus (Linnæus).

Fig. 307.—Strombus cancellatus (Lamarck).

Fig. 308 —Strombus thersites (Gray).

Fig. 309.—Pteroceras scorpio (Linnæus).

Fig. 310.—Pteroceras millepeda (Linnæus).

from those of *Strombus* chiefly in this, that the right edge develops itself with age into long and slender digital spines more or less numerous, the numbers of which vary according to the species. The

species of *Pterocera* are found in the seas of both hemispheres, their vulgar denomination being sea-spider or scorpion shells. A glance at the illustrations (Fig. 309, *Pteroceras scorpio;* Fig. 310, *P. millepeda;* Fig. 311, *P. chiragra;* and Fig. 312, *P. lambis*) will satisfy the reader as to the general correctness of this designation.

Fig. 311.—Pteroceras chiragra (Linnæus).

Fig. 312.—Pteroceras lambis (Linnæus).

The genus Pteroceras, whose remarkable form is so well calculated to excite our admiration, has yet another attraction: the colouring of the shells exhibits many shades, which are particularly varied towards the opening, where it is generally distinguished by great freshness and brilliancy, which, added to its other characters, render it among the most interesting of all the Gasteropods.

CHAPTER XVII.

PTEROPODS.

"Natura non facit saltus."—LINNÆUS.

THE position of the Pteropoda is somewhat unsatisfactory. Their organisation in some respects places them below the level of the Gasteropods; yet the general feeling amongst naturalists has been to assign them a place between the Gasteropods and the most highly organised of the molluscs, the Cephalopods. The number of genera and species is very much less than that of the other great classes of molluscs.

The principal characteristic of the Pteropoda is a membranous expansion situated on the right and left side of their head, from which they take their name of Pteropoda, from πτερὸν, wing, and ποῦς, gen. ποδὸς, foot, winged feet.

The wings or flappers with which they are provided enable them to pass rapidly through the water, reminding us strongly of the movements of a butterfly, or other winged insect, and like them, their motions are long continued. They advance in this manner in a given direction, while the body or the shell remains in an oblique or vertical position.

These little molluscs may be seen to ascend to the surface very suddenly, turn themselves in a determinate space, or rather swim, without appearing to change their place, while sustaining themselves at the same height. If anything alarms them they fold up their flappers, and descend to such a depth in their watery world as will give them the security they seek. They thus pass their lives in the open sea far from any other shelter, except that yielded by the gulf weed and other algæ. In appearance and habits, these small and sometimes microscopic creatures resemble the fry of some other forms of mollusca. They literally swarm both in tropical and arctic seas; and are sometimes so numerous as to colour the ocean for leagues. They are the principal food of whales and sea-birds in high latitudes, rarely approaching the coast. Only one or two

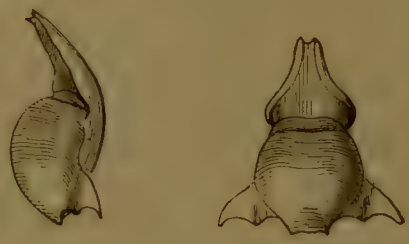
species have been accidentally taken on our shores, and those evidently driven thither by currents into which they have been entangled, or by tempests which have stirred the waters with a power beyond theirs. Dr. Leach states that in 1811, during a tour to the Orkneys, he observed on the rocks of the Isle of Staffa several mutilated specimens of *Clio borealis*. Some days after, having borrowed a large shrimp-net, and rowing along the coast of Mull, when the sea, which had previously been extremely stormy, had become calm, he succeeded in catching one alive, which is now in the British Museum.

"In structure," Mr. Huxley tells us, "the Pteropods are most nearly related to the marine univalves, but much inferior to them. Their numerous ganglia are concentrated into a mass below the œsophagus; they have auditory vesicles containing otolithes, and are sensible of light and heat, and probably of odours, although at most they possess very imperfect eyes and tentacles. The true foot is small or obsolete; in *Cleodora* (Fig. 317) it is combined with the fins; but in *Clio* it is sufficiently distinct, and consists of two elements; in *Spirialis* the posterior portion of the foot supports an operculum. The fins are developed from the sides of the mouth or neck, and are the equivalents of the side-lappets (*epipodia*) of the sea-snails. The mouth of *Pneumodermon* is furnished with two tentacles supporting miniature suckers; these organs have been compared to the dorsal arms of the cuttle-fishes; but it is doubtful whether their nature is the same. A more certain point of resemblance is the ventral flexure of the alimentary canal, which terminates on the under surface near the right side of the neck. The Pteropods have a muscular gizzard armed with gastric teeth, a liver, a pyloric cæcum, and a contractile renal organ opening into the cavity of the mantle. The heart consists of an auricle and a ventricle, and is essentially opisthobranchiatic, although sometimes affected by the general flexure of the body. The venous system is extremely incomplete. The respiratory organ, which is little more than a ciliated surface, is either situated at the extremity of the body, and unprotected by a mantle, or included in a branchial chamber with an opening in front. The shell when present is symmetrical, glassy, and translucent, consisting of a dorsal and a ventral plate united, with an anterior opening for the head, lateral slits for long filiform processes of the mantle, and terminated behind in one or three points; in other cases it is conical or spirally-coiled, or closed by a spiral operculum. The sexes are united, and the orifices are situated on the right side of the neck. According to Vogt, the embryo Pteropod

has deciduous vela like the sea-snails, before the proper locomotive organs are developed."

The Pteropods seem to be eminently sociable and gregarious, swarming together in great numbers; they present some analogical resemblances to the Cephalopoda; but permanently they represent the larval stage of the sea-snails. De Blainville divides the group into two sections, *Thecosomata* and *Gymnosomata*, the first including the *Hyaleidæ* and *Limacinidæ;* the second contains one family, the *Cliidæ*. Of these three principal families of Pteropods, the first, the *Cliidæ*, contains Cymodocea, Pelagia, Pneumodermon, and Clio; the second, *Limacinidæ*, contains Macgillivrayia, Cheletropis, Spirialis, and Limacina; the third, *Hyaleidæ*, contains Tiedemannia, Cymbulia,

Figs. 313 and 314.—Hyalea gibbosa (Rang.).



Figs. 315 and 316.—Hyalea longirostris (Lesueur).

Eurybia, Theca, Cleodora, and Hyalea. The Hyaleidæ have small horny shells, very thin and transparent, globular, or elongated, open anteriorly, cloven on the sides, and truncate at the posterior extremity. Their globular body is formed of two parts, the one including the head, bearing two very strong tentacles, and two large fins or flappers in the form of wings, springing from each side of the mouth.

These molluscs are small, and generally of a yellowish-blue or violet colour. They are inhabitants of the deep sea, and rarely seen out of what sailors call "blue water." They plough the waves with great rapidity by the aid of their powerful fins. Certain winds throw them sometimes in great numbers on the shores of the Mediterranean. These little creatures, so inoffensive, and living together in vast numbers, seem to be an easy and ready-prepared prey, which the great marine animals may swallow by thousands. Twenty species of *Hyalea* are described as actually living in the Atlantic and Australian seas. Of these *Hyalea gibbosa* (Figs. 313, 314) and *Hyalea longirostris* (Figs. 315, 316) are here represented.

The great flappers of *Hyalea tridentata* are yellow, marked at their base with a fine violet spot. Its shell, plain above, convex beneath, is cloven on the side. The superior part is longer than the inferior, and the transverse line which unites them is furnished with three teeth. This shell is yellow, and nearly translucent. When

Fig. 317.
Cleodora lanceolata (Lesueur).

Fig. 318.
Cleodora compressa (Eydoux and Souleyet).

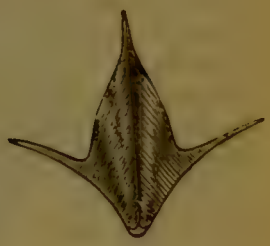


Fig. 319.
Cleodora cuspidata (Bocc.).

the animal swims, two expansions of its mantle issue from the lateral clefts in the shell.

Cleodora lanceolata is a delicate and graceful creature; its body, of gelatinous appearance, has a distinct head, with its fins near the neck, notched in the form of a heart (Fig. 317); its posterior part is globulous, transparent, and luminous even in the dark. The animal which inhabits it sometimes shines through the shell like a light placed inside a lantern. This shell is triangular, as in *Cleodora cuspidata* (Fig. 319), thin, vitreous, and fragile, terminating in a long spine at the base. The shell in *Cleodora compressa* (Fig. 318) is elongated and very elegant in shape.

CHAPTER XVIII.

MOLLUSCA CEPHALOPODA.

"Monstrum horrendum, informe, ingens."—VIRGIL.

THE highest class of the Mollusca is the Cephalopoda, which has been divided by Professor Owen into two orders, *Tetrabranchiata*, or animals having four branchiæ, and the *Dibranchiata*, having two branchiæ. The first order, *Tetrabranchiata*, contains the family *Ammonitidæ*, with the fossil genera *Goniatites* and *Ammonites;* the family *Orthoceritidæ*, the fossil genera *Gomphoceras* and *Orthoceras;* and the family *Nautilidæ*, with the genus *Nautilus*.

The name Cephalopoda, as already stated, is taken from the position of their feet, or more properly their arms, which are inserted in the anterior part of the head: in Greek κεφάλη, head, ποῦς-ποδός, *foot*.

The Cephalopodous Molluscs are indeed highly organised for Molluscs, for they possess in a high degree the sense of sight, hearing, and touch. They appear with the earlier animals which present themselves on the earth, and they are numerous even now, although they are far from playing the important part that was assigned to them in the early ages of organic life upon our planet. The *Ammonites* and *Belemnites* existed by thousands among the beings which peopled the seas during the Secondary epoch in the history of the globe.

TETRABRANCHIATA.

In this order the animal is creeping, protected with an external shell; the head is retractile within the mantle; the eyes are pedunculated; the mandibles are calcareous; there are very numerous arms. The shell is external, camerated, and provided with a siphuncle, or membranous tube (*Nautilus*), with a thin nacreous investment. In many fossil forms it consists of a number of funnel-shaped or bead-like tubes. This order differs from that of the *Dibranchiata* chiefly in their more numerous arms, which are quite tentaculiferous, in

the branchiæ or gills being four, in having no suckers, and in having an external shell. The number of living species is extremely small—for this group of animals belongs peculiarly to the earlier ages of our globe—is gradually becoming extinct, and presents in our days only some species very rare and few, especially when we compare them with the prodigious numbers of these beings which animated the seas of the ancient world. In fact, the only living genus of the order is that of *Nautilus*, the external shell of which has a singular resemblance in form to the internal shell of the genus *Argonauta*.

In *Nautilus* the shell has a regularly convoluted form, the last whorl being equal to all the others. It is divided internally into

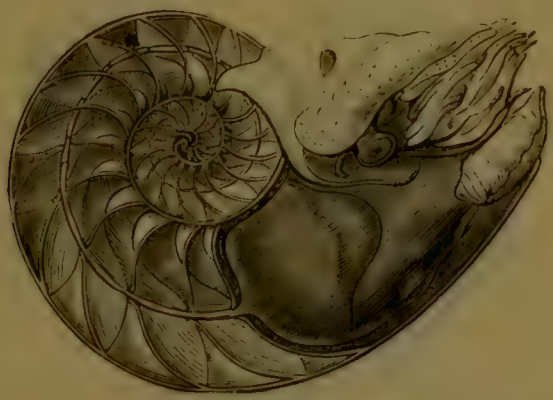


Fig. 320.—Nautilus pompilius (Linnæus), showing the interior of the lower cell, to which the animal is fixed.

numerous cells, formed by transverse partitions, concave in front and perforated towards the centre, and forming a kind of funnel, which gives passage to a respiratory syphon.

In the last partition of the shell (Fig. 320) is the animal, covered by its mantle, which lines the walls of the partitions. When it contracts itself it is protected by a sort of triangular and fleshy hood. Numerous tentacles, which are retractile, within sheaths, or "digitations," corresponding to the eight ordinary arms of a cuttle-fish, and some of them furnished with numerous lamellæ, surround the head, which is, besides, scarcely distinguished from the body. The head bears two great projecting eyes, each planted upon a peduncle.

Like *Sepia* and *Octopus*, the mouth of the *Nautilus* is armed with mandibles, fashioned somewhat like the parrot's beak. The branchiæ, as we have seen, are four in number; the circulatory system consists

of a heart, with a ventricle and auricle. The shell is secreted by the outer edge of the mantle, while its posterior extremity fashions the walls of the partitions, which indicate the successive growth of the individual.

Fig. 321 represents the shell of *Nautilus*, with the animal removed; the last partition is seen empty, and with the perforations through which the siphuncle passes.

The genus *Nautilus* inhabits the Indian Ocean and the sea round the Molucca Islands. In swimming, the head and tentacles are projected from out of the shell. In walking on rocks, they drag themselves along the ground, the body upwards, the head and

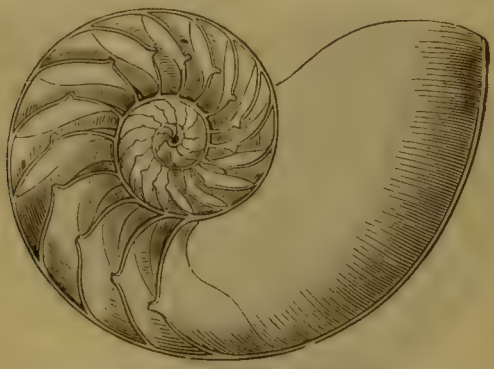


Fig. 321.—Nautilus pompilius (Linnæus).
showing the lower cell and the partition giving passage to the siphon.

tentacles beneath. They betake themselves frequently to miry cavities frequented by fish. It is a much more common occurrence to find the empty than inhabited shells of the *Nautilus* at sea. This probably arises from its exposure to the attacks of crustaceans and other marine animals, which seems to be proved by the mangled appearance of the edges of the empty shells thus met with.

The Pearly Nautilus, *Nautilus pompilius* (Fig. 322), is said to be so common on the Nicobar coast that the inhabitants salt and dry its flesh, and store it as provisions. Its shell attains about eight inches in its greatest height. This shell is said to be still used by the Hindoo priests as the conch with which they summon their devotees to worship. It is nearly round, smooth, transversely blazed in its posterior part, and entirely white anteriorly. A very fine nacre is yielded by this mollusc, which is much used in ornamental cabinet-work. The Orientals make drinking-cups, on which they engrave

designs and figures, which form graceful objects. Similar vases were formerly shaped in Europe, which found their way into great houses. In our days they are generally consigned to cabinets of curiosities and the shops of dealers in articles of *vertu*.

DIBRANCHIATA.

Owen's second order, *Dibranchiata*, contains six families: The first is *Spirulidæ*, containing the curious genus *Spirula*, that little gem amongst oceanic shells. The second family is *Sepiadæ*, containing the genus *Sepia*. The third is *Belemnitidæ*, with the genera

Fig. 322.—Shell of Nautilus pompilius (Linnæus).

Belemnites, and *Belemnoteuthis*. The fourth, *Teuthidiæ*, with *Loligo*, *Sepiola*, *Ommastrephes*, and others. The fifth, *Octopodæ*, with *Octopus* and *Eledone*. And the sixth, *Argonautidæ*, with the genus *Argonauta*. The order is most conveniently divided into two sections: the first, those Dibranchiates with eight arms—*Octopoda*, including the last two families; the second, those with ten arms—*Decapoda*, including the first four families.

To this group belong the Cuttle-fish, Squids, and Argonauts, among existing species, and the Belemnites among the fossil species. Some of these creatures are large, and essentially flesh-eaters, or carnivorous; and, if we may believe all that has been written respecting them, very formidable ones. Listen to Michelet, while he wonderfully paints the humour of these inhabitants of the deep:—"The Medusæ and Molluscs," says this popular author, "are generally innocent

creatures, and I have lived with them in a world of gentle peace. Few flesh-eaters among them; those even which are so, only kill to satisfy their wants, living for the most part on life just commenced—on gelatinous animals which can scarcely be called organic. From this world grief was absent. No cruelty and no passion. Their little souls, if mild, were not without their ray of aspiration towards the light, and towards what comes to us from heaven, and towards that love, revelling in that changing flame which at night is the light of the deep. It is now, however, necessary to describe a much graver world: a world of rapine and of murder; from the very beginning, from the first appearance of life, violent death appeared; sudden refinement, useful but cruel purification of all which has languished, or which may linger or languish, of the slow and feeble creation whose fecundity had encumbered the globe.

"In the more ancient formations of the old world we find two murderers—a nipper and a sucker. The first is revealed to us by the imprint of the trilobite, an order now lost, the most destructive of extinct beings. The second subsists in one gigantic fragment, a beak nearly two feet in length, which was that of a great sucker or cuttle-fish (*Sepia*). If we may judge from such a beak, this monster—if the other parts of the body were in proportion—must have been enormous; its ventose, invincible arms, of perhaps twenty or thirty feet, like those of some monstrous spider. In making war on the molluscs he remains mollusc also; that is to say, always an embryo. He presents the strange, almost ridiculous, if it was not also terrible, appearance of an embryo going to war; of a fœtus furious and cruel, soft and transparent, but tenacious, breathing with a murderous breath, for it is not for food alone that it makes war: it has the wish to destroy. Satiated, and even bursting, it still destroys. Without defensive armour, under its threatening murmurs there is no peace; its safety is to attack. It regards all creatures as a possible enemy. It throws about its long arms, or rather thongs, armed with suckers, at random." Such is the somewhat exaggerated picture which the eloquent historian and poet draws of the Molluscous Cephalopod, and perhaps it must be admitted that there is some little basis of truth in this, though there is scarcely any in the more recent one which has been painted by the more imaginative Victor Hugo, in his eloquent book, entitled "Les Travailleurs de la Mer." Where, however, there is so much of the fictitious, it will be our earnest endeavour to eliminate facts only.

These formidable and curious Cephalopods, the Μαλάκια of Aristotle, *Mollia* of Pliny, and *Cephalophora* of De Blainville, have the

mantle, according to Cuvier, united beneath the body, thus forming a muscular sac which envelopes the whole viscera. The body is soft and fleshy, varying much in form, being sub-spherical, sub-elliptical, and cylindrical, the sides of the mantle in many species extending into fleshy fins. The head protrudes from the muscular sac, and is distinct from the body; it is gifted with all the usual organs of sense, the eyes in particular, which are either pedunculate or sessile, being large and well developed. The mouth is anterior and terminal, armed with a pair of horny or calcareous mandibles, which bear a strong resemblance to the bill of a parrot, acting transversely, one upon the other. Its position is the bottom of a sub-conical cavity, forming the base of numerous fleshy tentacular appendages which surround it, and which are termed arms by some writers. These appendages in the great majority of living species are provided with suckers, *acetabula* (cupping-glass-like appendages), by means of which the animal moves at the bottom of the sea, head downwards, or attaches itself to its prey. These suckers are armed or unarmed with a long, sharp, horny claw. In the unarmed acetabula, the mechanism for adhesion is well described by Dr. Roget. "The circumference of the disc," says this writer, "is raised by a soft and turned margin; a series of long slender folds of membrane covering corresponding fascicula of muscular fibre converge from the circumference towards the centre of the sucker, at a short distance from which they leave a circular aperture; this opens into a cavity which widens as it descends, and contains a cone of soft substance rising from the bottom of the cavity, like the piston of a syringe. When the sucker is applied to the surface for the purpose of adhesion, the piston, having previously been raised so as to fill the cavity, is retracted, and a vacuum produced, which may be still further increased by the retraction of the plicated portion of the disc." Here we have an excellent description of the apparatus for holding on. When the animal is disposed to let go his hold, according to Professor Owen, "the muscular arrangement enables it to push forward the piston, and thus in a moment destroy the vacuum which retraction had produced."

In the case of the Cephalopods, with the arms and tentacles armed, as *Onychoteuthis*, Professor Owen remarks, "that there are circumstances in which even the remarkable apparatus described by Dr. Roget would be insufficient to fulfil the offices in the economy of Nature for which the Cephalopod was created, and that in species which have to contend with the agile mucous fishes more powerful organs of prehension are superadded to the suckers, so that in the armed Calamary the base of the piston is, he remarks, enclosed in a

horny hoop, the outer and anterior margin of which is developed into a series of sharp curved teeth, which can be firmly pressed into the flesh of a struggling prey by the contraction of the surrounding transverse fibres, and can be withdrawn by the action of the retracting fibres of the piston. "Let the reader," the Professor adds, "picture to himself the projecting weapon of the horny hoop developed into a long, curved, sharp-pointed claw, and these weapons clustered at the expanded terminations of the tentacles, and arranged in a double alternate series along the internal surface of the eight muscular feet, and he will have some idea of the formidable nature of the carnivorous cephalopod." The Professor notices another structure which adds greatly to the prehensile powers of the uncinated Cephalopods. "At the extremities of the long tentacles a cluster of small, simple, unarmed suckers may be observed at the base of the expanded part. When these latter suckers are applied to one another, the tentacles are firmly locked together at that part, and the united strength of both the elongated peduncles can be applied to drag towards the mouth any resisting object which has been grappled by the terminal hooks. There is no mechanical contrivance which surpasses this structure; art has remotely imitated it in the fabrication of the obstetrical forceps, in which either blade can be used separately, or, by the interlocking of a temporary blade, be made to act in combination." *

If we study the general aspect of the animal more closely, we find that the arms—which serve at once as organs of locomotion for swimming, for creeping, and as prehensile organs for seizing and retaining its prey—are conical, very long, and all of the same form. Each of them has towards its axis a longitudinal canal, which encloses a great nerve, and is also surrounded with muscular fibres, arranged in rays. The suckers, already described, occupy all the internal surface of the eight tentacular arms, which are arranged in two rows, having the form very nearly of a semi-spherical capsule. Of these suckers, each arm of the cuttle-fish carries about 240, the total number being nearly 1,000. The mouth we have already described, in Dr. Roget's words: "The teeth move vertically, much as the cutting edge of the two blades of a pair of scissors move upon each other, tearing the prey by the assistance of their hooked terminations."

The tongue is covered on its upper part by a thick horny surface, bristling in the centre with a series of recurved teeth, while its edge is armed with three other erect teeth, which are slender and hooked. The œsophagus is long and slender. At the abdomen the gullet

* "Cyclopædia of Anatomy."

expands into a sort of pouch, to which succeeds a gizzard, with strong fleshy walls; and, finally, a very short intestine, which directs itself forward, terminating on the median line of the body.

Towards the anterior parts is the branchial cavity, of which a few words must be said. It occupies the free space comprised between the exterior surface of the abdomen and the internal face of the mantle; and here the respiratory organs, namely, the *branchiæ*, are lodged. Here, also, are the reproductive and excretory organs.

The branchiæ, which in all the families of this order are two in number, are voluminous, but short, tufted, and leaf-like. The branchial cavity can dilate and contract itself alternately. It communicates externally by two openings: the one, fashioned into a cleft, receives, while the other, which is prolonged into a funnel, serves to eject, the water, and thereby becomes a powerful organ of locomotion. The inspiration of the animal is thus made by a cleft in the mantle, and expiration is effected by the funnel: the renewal of the respirable liquid acts as a sort of sucking and forcing pump, at the surface of the lamelliform branchiæ.

The cuttle-fish would be at no loss to reply to the question of the Don Diego of Corneille—

"Rodrique, as-tu du cœur?"

for they have three hearts. Besides the ordinary systemic heart, the circulation is aided by two additional ones placed at the end of the branchiæ. With each beat of the pulse the venous blood is brought from all parts of the body, and propelled through each gill or branchiæ. Vivified by respiration in the internal tissue of the branchiæ, it is carried by the veins into the third (systemic) heart, situated upon the median line of the body; and now the regenerated fluid is again distributed throughout the rest of the economy.

Not to oppress the reader with anatomical details, we shall just remark that the gaze of the cuttle-fish is decided and threatening. Its projecting eyes and golden-coloured iris are said to have something of fascination in them. The animal seems able even to economise the power of its glance, being able to cover its eyes from time to time by contracting the skin which surrounds them, and bringing the two translucent eyelids with which it is furnished together.

The cuttle-fishes are essentially aquatic and marine animals. We find them in every sea in all parts of the world; but they are most formidable in warm countries. They have a great predilection for the shore. During their youth they associate in flocks; but with age they fly from association, and retire into the clefts and hollows of the

rocks. The old cuttle-fish is only found in rugged and rocky places, bristling with naked, pointed rocks, which have been worn by the waves, but generally in places only a few feet below the level of low water. "How often," says d'Orbigny, "have we not observed the cuttle-fish in his favourite retirement! There, with one of his arms clasped to the walls of its dwelling, it extends the other towards the animals which pass at its gate, embraces them, and by its power renders useless all their efforts to disengage themselves."

If we observe a cuttle-fish when it is what may be called walking, either on land or at the bottom of the sea, it will be seen to walk on one side, its head downwards, its mouth touching the ground, the arms extending and grappling some supporting object, and drawing the body forward; at the same time the arms at the opposite side are contracted and folded up, so as to assist by a contrary movement. On shore the movement of these animals is very slow. On the other hand, they swim very rapidly, assisted by all their arms, and aided by the water ejected from the funnel, their movement being most frequently backwards, the body first, the six superior arms placed horizontally, the two others brought together above: the first help to sustain them in their horizontal position, the last to guide them, inclining to the right or left as the animal changes its direction.

The cuttle-fishes feed on crustaceans, fishes, and also on shelled molluscs—every kind of animal, in fact, which comes within their reach; so that it is readily taken by means of the flesh of fish or crustaceans in which a strong hook is concealed. They live for five or six years, and lay eggs, which are large, and generally found in clusters; fishermen know them under the name of *sea-grapes*.

Like some of the lower animals, they possess the property of re-integration, being able to reproduce any arm that may be destroyed. There is another singular peculiarity which the cuttle-fish may be said to share with man. Under the influence of strong emotion the human face becomes pale, or blushes, and in some individuals it is said to become blue. This has always been supposed to be an attribute of humanity; but the cuttle-fish shares it with our race. Yielding to the impressions of the moment, the cuttle-fish suddenly changes colour, and, passing through various tints, it only resumes its familiar one when the cause of the change has disappeared. They are, in fact, gifted with great sensibility, which reacts immediately upon their tissues, these being extremely elastic and delicate. Sudden changes of colour are produced—changes which far exceed the same phenomena in man. Under the influence of passion or emotion, man is born to blush, but under no sort of excitement does he cover

himself with pustules; this the cuttle-fish does: it not only changes colour, but it covers itself with little warts. "Observe a cuttle in a pool of water," says d'Orbigny, "as it walks round its retreat—it is smooth, and of a very pale colour. Attempt to seize it, and it quickly assumes a deeper tint, and its body becomes covered on the instant with warts and excrescences, which remain there until its confidence is entirely restored."

The following fact is abbreviated from the "Natural History and Fishery of the Sperm Whale." Mr. Beale had been searching for shells among the rocks in Bonin Island, and was much astonished to see at his feet a most extraordinary-looking animal, crawling back towards the surf which it had just left. It was creeping on its eight legs, which, from their soft and flexible nature, bent considerably under the weight of its body, so that it was just lifted by an effort above the rocks. It appeared much alarmed, and made every attempt to escape. Mr. Beale endeavoured to stop it by putting his foot on one of its tentacles, but it liberated itself several times in spite of all his efforts. He then laid hold of one of the tentacles with his hand, and held it firmly, and the limb appeared as if it would be torn asunder in the struggle. To terminate the contest, he gave it a powerful jerk; it resisted the effort successfully, but the moment after the enraged animal lifted a head with large projecting eyes, and loosing its hold of the rocks, suddenly sprang upon Mr. Beale's arm, which had been previously bared to the shoulder, and clung to it with its suckers, while it endeavoured to get the beak, which he could now see between the tentacles, in a position to bite him. Mr. Beale describes its cold slimy grasp as extremely sickening, and he loudly called to his friend, who was also searching for shells, to come to his assistance. They hastened to the boat, and he was released by killing his tormentor with a boat-knife, when the arms were disengaged bit by bit. Mr. Beale states that this Cephalopod must have measured across its expanded arms about four feet, while its body was not bigger than a large hand clenched. It was the species called the rock-squid by whalers.

The *Spirulidæ*.—This family contains but a single genus, *Spirula*, and but one or two perfect specimens of the perfect animal of *S. peronii* have been found. The shell is very common, and is found scattered by thousands on the shores of New Zealand. The shell is entirely nacreous-discoidal; the whorls are separate, and the last chamber is not larger in proportion than the rest.

The *Sepiadæ* have eight arms rising from the crown of the head, armed with four rows of suckers, two long slender arms with broadly-

expanding ends, and stalked suckers (Fig. 323); eyes moving in their sockets, and in Sepia the body is broadly ovate.

The body of the cuttle-fish (*Sepia*, Fig. 324), is a very singular structure, somewhat reminding us of certain species of polyps. We find a body or abdominal mass, separated by compression from the head, which is sufficiently marked. The body is covered by the mantle, which has the form of a sac opened only in front by a transverse cleft. The head has a projecting and well-developed eye on

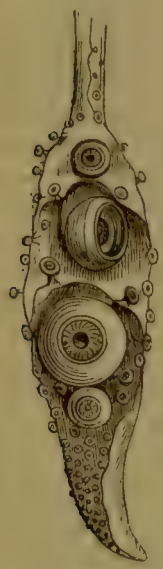


Fig. 323.
Sepia tuberculosa (Lamarck), arm of.

Fig. 324.
Sepia officinalis (Linnæus.)

Fig. 325.
Internal shell of Sepia officinalis.

each side; it is crowned by a sort of fleshy receptacle, which is surrounded by four or five pairs of tentacles. At the bottom of this receptacle is the mouth; and from the anterior opening in the mantle the funnel issues, which is wide at its base.

The body is also bordered on all its length on both sides with a wing or narrow fin; it is broader than it is long, with two large eyes, covered by an expansion of the skin, which becomes transparent over a surface equal to the diameter of the iris, and furnished with inferior contractile eyelids.

The skin of the cuttle-fish contains in one vast hollow, occupying all the extent of the back, a great calcareous shell, the form and

structure of which is quite characteristic of this genus. It is known as the cuttle-bone (Fig. 325). This bone is used for many purposes; among others, it is used in a powdered state as a dentifrice. It is sometimes suspended in the cage with captive birds, that they may whet their beaks on it, and collect phosphate of lime for the formation and repair of their bones. The shell is oval or oblong, sometimes provided with a slightly salient point. The upper part is surrounded with a horny or cretaceous margin, and it presents in the centre a combination of open cells.

Some of the Cephalopods secrete a blackish, inky fluid, the uses of which, in the economy of the animals, is imperfectly known. The cuttles have considerable quantities of this liquor, which is contained in a sort of sac or ink-bag, placed low down in the abdomen. When the animal is pursued or threatened with danger it discharges a jet of the fluid, which renders the water thick and muddy, and permits it to escape in the obscurity from its pursuers. It appears that the cuttle-fish avails itself of this stratagem when left accidentally ashore. It is related of an English officer, that, having dressed for dinner, and having some time to spare, he proceeded along the shore on his favourite search for objects of natural history. He reached a hollow rock in which a cuttle-fish had established its quarters; he soon detected the animal, which looked at him for some time with its great prominent eyes; and for a little they watched each other with fixed attention. This mute contemplation came to a sudden and unexpected termination by the discharge of a voluminous jet of inky fluid, that covered the officer, which was the more unfortunate, since he was in his summer dress of white trousers.

The ink of the cuttle-fish is a favourite pigment, used in water-colour painting under the name of *sepia*. It is truly indestructible; and the hard and black substance found in the sac of fossil species o cuttle-fish when diluted with water produces a brilliant sepia. This property of the inky fluid was well known to the Romans, who used it in making ink. It was long supposed to be the chief ingredient in Indian ink; but a recent traveller, Mr. Siebold, who has visited the manufactory, and investigated the subject, has revealed the true process by which Indian ink is prepared.

The species of the genus *Sepia* affect the sea-shore; they are along-shore molluscs. The flattened form of their bodies is favourable to a coasting life, by permitting them to rest easily on the bottom. Still they do not remain all the year round upon the coast. The cold in temperate regions, and the extreme heat in warm regions, lead them to withdraw from the shore, to which they only return in the

spring. They are rarely seen in the Channel in winter; but with the vernal sun they appear in large shoals. What is the mechanism by which these animals are moved? When the cuttle-fish wishes to swim rapidly and backwards, it advances in the water by means of the funnel which ejects the ambient liquid. When they wish to approach a prey slowly in order to seize it, they swim by the aid of their fins and arms.

The sepiæ are flesh-eaters, and tolerably voracious. They feed upon fishes, molluscs, and crustaceans. They are also true aquatic brigands, who kill, not to feed themselves, but for the sake of killing; and Nature, by a just equilibrium, applies to them the *lex talionis.* They fall victims, in their turn, to the vengeful jaws of the porpoises and dolphins. Such is the terrible law of Nature: some must die that others may live. Michelet gives us a glimpse of the manner in which the dolphins dispose of the cuttle-fish in his "Livre de la Mer." "These lords of the ocean," he says, "are so delicate in their tastes that they eat only the head and arms, which are both tender and easy of digestion. They reject the hard parts, and especially the after-part of the body. The coast at Royan, for example, is covered with thousands of these mutilated cuttle-fish. The porpoises take most incredible bounds, at first to frighten them, and afterwards to run them down; in short, after their feast they give themselves up to gymnastics."

In the spring the sepiæ deposit their eggs, but without abandoning them. On the contrary, they exhibit a truly maternal care, taking much trouble to attach them to some submarine body, in which position the temperature of the water serves to hatch the eggs. *Sepia officinalis*, for example, chooses, at the moment of laying, a stem of *Fucus*, or of *Gorgonia*, or some other solid submarine body not less in diameter than the little finger, and there it firmly attaches its eggs, which are pear-shaped, that is, pointed at one extremity, while a long *lanière* of a gelatinous nature, flat and black in appearance, with which they are provided, surrounds the solid body like a ring. Each female lays and attaches in this manner from twenty to thirty eggs, which are clustered together somewhat like a bunch of fine black grapes (Fig. 326). About a month after this the eggs are hatched.

The colours of *Sepia officinalis* vary considerably; but in general it may be remarked that the males are ornamented with deeper colours than the females. Transverse bands of a blackish brown furrow their backs, and seem to take from their breadth. Outside of these bands are small spots of a vivid white; very near the edge

ıere is a white border, accompanied inside with a second edging of beautiful violet. The median and anterior parts of the body are ɔotted here and there; beneath, a whitish tint with reddish speckles :evails.

The sepiæ are found on every shore, and wherever they are found ıey are eaten, for their flesh is savoury. They are usually fried or ɔiled. They form an excellent bait for large ground-fish, such as ɔg-fish, rays, and congers, which are fond of their flesh.

Thirty species are known, and they are chiefly characterised by .e arrangement and form of the suckers of the arms. *Sepia officinalis* common on the shores of the ocean from Sweden to the Canaries, all parts of the Mediterranean, and on our own British shores.

Fig. 326.—Sepia officinalis (Linnæus).

The third family, *Belemnitidæ*, contains the genera *Belemnoteuthis* ıd *Belemnites*, and other genera of less importance; they are all ɔw extinct, although once numerous as to species.

The fourth family, *Teuthidæ*, contains *Loligopsis*, *Cranchia*, *piola*, *Onychoteuthis*, *Loligo*, and others.

The *Calamaries* or Squids were described by Aristotle under the ıme of Τείφις, and by Pliny under that of *Loligo*, which is still tained as the name of one genus. Their popular name of Calmar alamar in old French) is taken from their resemblance to certain ecies of ink-holders. Oppian, who endowed the Argonaut with ngs, believed that the calmar also could take to the air, in order to oid his enemies. Nevertheless, he was much puzzled how to give e form and functions of a bird to a fish. Themistocles, by way of sult to the Eretrians, likened them to calmars, saying they had 'ords and no hearts. Athenæus, a Greek physician before Galen, velt upon the nourishing properties of the flesh of the calmar.

The calmars, common enough in temperate regions, abound in the seas of the torrid zone; they are gregarious, and live in numerous shoals, these flocks taking every year the same direction, their emigration proceeding from temperate to warm regions—nearly the same course as that followed by the herrings and pilchards.

The calmars, like the cuttles, propel themselves backwards through the water with great velocity, driving back the water by means of their funnel, moving with such vigour and promptitude that they have been known to throw themselves out of the water, falling on the shore

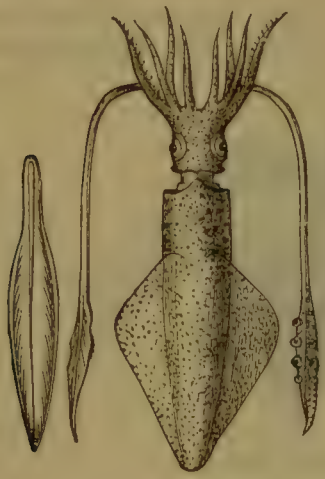


Fig. 327.—Loligo vulgaris, with its pen, or internal bone (Lamarck).

Fig. 328.—Loligo Gahi (d'Orbigny).

or on the deck of a vessel. They only appear momentarily on the shore, and only sojourn there to deposit their eggs, which are gelatinous in substance, about the level of the lowest tides. The body in the calmars is longer than in the cuttle-fish, cylindrical in shape, and terminating in a point, having two lateral fins, which occupy the lower half or one-third of its body.

In the common calmar, *Loligo vulgaris* (Fig. 327), and the *Loligo Gahi* (Fig. 328), we have two extreme forms represented, both taken from the magnificent work of MM. d'Orbigny and Ferussac, on the *Cephalopodes acetabulifores.* These molluscs are whitish-blue and transparent, covered with spots of bright red. The pen is lanceolate—that of the male elongated and somewhat resembling a feather, that of the female much broader and more obtuse. Their head is short,

furnished with two large projecting eyes; the mouth is surrounded with ten arms, provided with suckers, two of these arms being much longer than the others, and with peduncles or foot-stalks to the suckers.

The internal pen of the calmar differs much from that of the cuttles; it is thin, horny, transparent, and somewhat resembling a feather, from a portion of which the barbs have been removed. Their food consists chiefly of small fishes and molluscs, though with the greater fishes and cetaceæ they carry on constant war. They are caught and used for various purposes; along the coast they are eaten; the fishermen use them as bait, especially in fishing for cod.

Dr. Grant describes the body of *Sepiola vulgaris*, found on our coast, as measuring about two inches in length, and as much in breadth, while the head measures half an inch in length, and, from the magnitude of the eyes, is equal in breadth with the body. In *Onychoteuthis*, distinguished for its uncinated suckers, the eyes are of the size of those of a man. In Cook's first voyages, the naturalists to the expedition, Banks and Solander, to quote Professor Owen's account, "found the dead carcase of a gigantic species of this kind floating in the sea between Cape Horn and the Polynesian Islands, in 30° 44′ S. lat., and 110° 10′ W. long. It was surrounded by sea birds, which were feeding on its remains. From the parts of this specimen which are still preserved in the Hunterian Museum, and which have always strongly excited the attention of naturalists, it must have measured at least six feet from the end of the tail to the end of the tentacles."

It is no easy task to separate the real from the fabulous history of the Cephalopods. Aristotle and Pliny have alike assisted, by their marvellous relations, to throw that halo of wonder round it which the light of modern science has not altogether dispelled. Pliny the Ancient relates the history of an enormous cuttle-fish which haunted the coast of Spain, and destroyed the fishing-grounds. He adds that this gigantic creature was finally taken, that its body weighed 700lbs., and that its arms were ten yards in length. Its head came by right to Lucullus, to whose gastronomical privileges be all honour. It was so large, says Pliny, that it filled fifteen amphoræ, and weighed 700lbs. also.

Some naturalists of the Renaissance, such as Olaüs Magnus and Denis de Montfort, gave credit—which they are scarcely justified in doing—to the assertions of certain writers of the north of Europe, who believed seriously in the existence of a sea-monster of prodigious size which haunted the northern seas. This monster has received the name of the *Kraken*. The Kraken was long the terror of these seas; it arrested ships in spite of the action of the wind, sails, and oars,

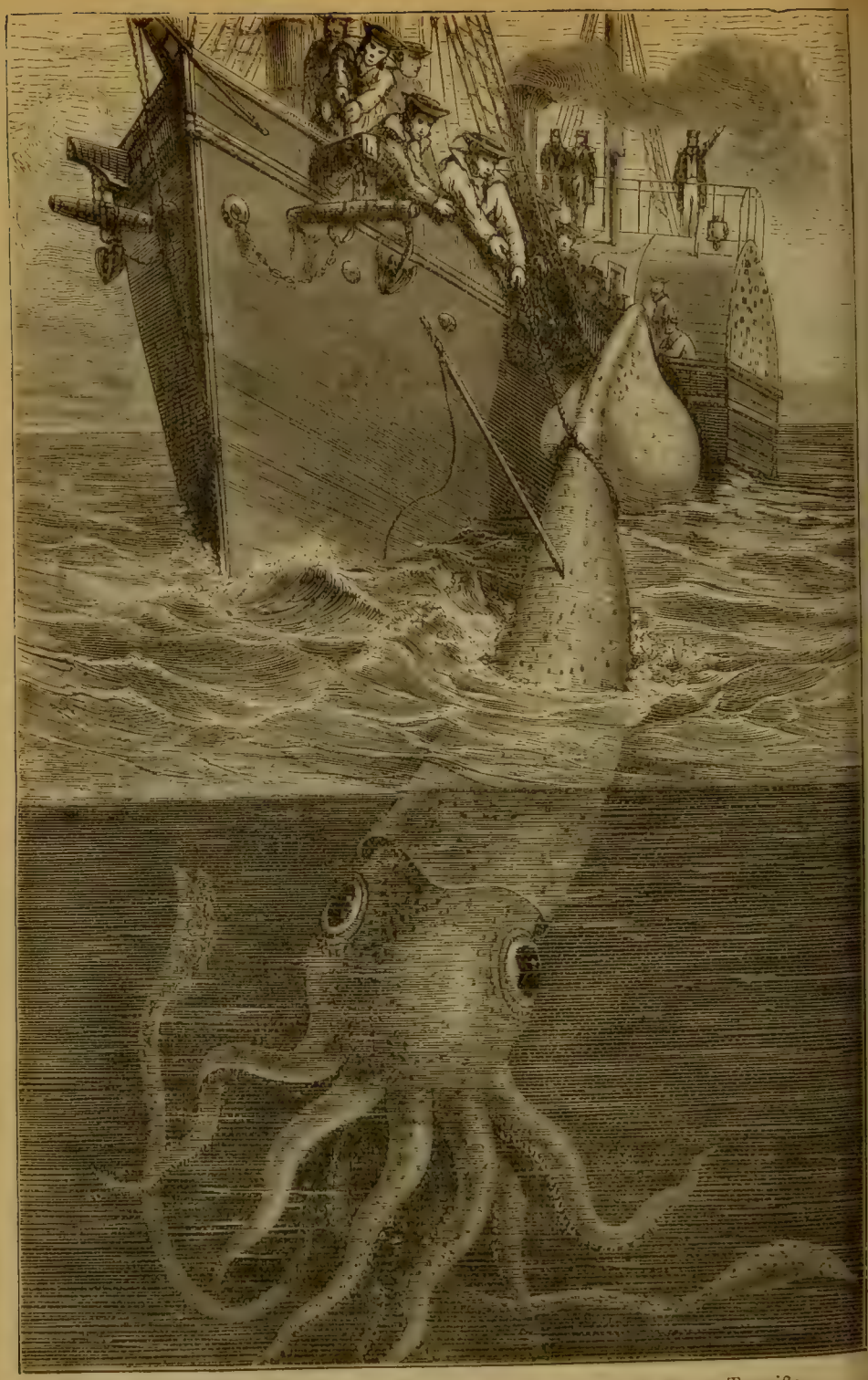
often causing them to founder at sea, while the cause of shipwreck remained unsuspected. Denis de Montfort gives a description and representation of this Kraken, which he calls the Colossal Poulpe, in which the creature is made to embrace a three-masted ship in its vast arms. Delighted with the success which his representation met with, Denis laughed at the credulity of his contemporaries. "If my Kraken takes with them," he said, "I shall make it extend its arms to both shores of the Straits of Gibraltar." To another learned friend he said, "If my entangled ship is accepted, I shall make my Poulpe overthrow a whole fleet."

Among those who admitted the facetious history of the Kraken without a smile, there was at least one holy bishop, who was, moreover, something of a naturalist. Pontoppidan, Bishop of Bergen, in Norway, in one of his books assures us that a whole regiment of soldiers could easily manœuvre on the back of the Kraken, which he compares to a floating island. "Similior insulæ quam bestiæ," wrote the good Bishop of Bergen.

In the first edition of his "System of Nature," Linnæus himself admits the existence of this colossus of the seas, which he calls *Sepia microcosmos*. In subsequent editions, however, he erased the Kraken from his catalogue.

The statements of Pliny respecting the Colossal Poulpe, like those of Montfort about the Kraken, are evidently fabulous. It is, however, an undisputed fact that there exists in the Mediterranean and other seas cuttle-fish of considerable size. A calmar has been caught in our own time, near Nice, which weighed upwards of thirty pounds. In the same neighbourhood some fishermen caught, twenty years ago, an individual of the same genus nearly six feet long, which is preserved in the Museum of Natural History at Montpellier. Péron, the naturalist, met in the Australian seas a cuttle-fish nearly eight feet long. The travellers Quoy and Gaimard picked up in the Atlantic Ocean, near the equator, the skeleton of a monstrous mollusc, which, according to their calculations, must have weighed 200 pounds. M. Rang met in the middle of the ocean a mollusc with short arms and of a reddish colour, the body of which, according to this naturalist, was as large as a tun cask. One of the mandibles of this creature still preserved in the Museum of the College of Surgeons, is larger than a hand.

In 1853 a gigantic Cephalopod was stranded on the coast of Jutland. The body of this monster, which was dismembered by the fishermen, furnished many wheelbarrow loads, its pharynx, or back part of the mouth, alone being as large as the head of an infant.



XXII.—Gigantic Cuttle-fish caught by the French Corvette *Alecton*, near Teneriffe.

Dr. Steenstrup, of Copenhagen, who published a description of this creature under the name of *Architeuthis dux*, shows a portion of the arm of another Cephalopod, which is as large as the thigh-bone of a man. But an apparently well-authenticated fact connected with these gigantic Cephalopods is related by Lieutenant Bayer, of the French corvette *Alecton*, and M. Sabin Berthelot, French Consul at the Canary Islands, by whom the report is made to the Académie des Sciences.

The steam-corvette *Alecton* was between Teneriffe and Madeira when she fell in with a gigantic calamar, not less—according to the account—than fifteen mètres (fifty feet) long, without reckoning its eight formidable arms, covered with suckers, and about twenty feet in circumference at its largest part, the head terminating in many arms of enormous size, the other extremity terminating in two fleshy lobes or fins of great size, the weight of the whole being estimated at 4,000 lbs.; the flesh was soft, glutinous, and of reddish-brick colour.

The commandant, wishing in the interests of science to secure the monster, actually engaged it in battle. Numerous shots were aimed at it, but the balls traversed its flaccid and glutinous mass without causing it any vital injury. But after one of these attacks the waves were observed to be covered with foam and blood, and, singular thing, a strong odour of musk was inhaled by the spectators. This musk odour we have already noticed as being peculiar to many of the Cephalopods.

The musket-shots not having produced the desired results, harpoons were employed, but they took no hold on the soft impalpable flesh of the marine monster. When it escaped from the harpoon it dived under the ship, and came up again at the other side. They succeeded at last in getting the harpoon to bite, and in passing a bowling hitch round the posterior part of the animal. But when they attempted to hoist it out of the water the rope penetrated deeply into the flesh, and separated it into two parts, the head with the arms and tentacles dropping into the sea and making off, while the fins and posterior parts were brought on board: they weighed about forty pounds.

The crew were eager to pursue, and would have launched a boat, but the commander refused, fearing that the animal might capsize it. The object was not, in his opinion, one in which he could risk the lives of his crew. PLATE XXII. is copied from M. Berthelot's coloured representation of this scene. "It is probable," M. Moquin-Tandon remarks, commenting on M. Berthelot's recital, "that this colossal mollusc was sick or exhausted by some recent struggle with

some other monster of the deep, which would account for its having quitted its native rocks in the depths of the ocean. Otherwise it would have been more active in its movements, or it would have obscured the waves with the inky liquid which all the Cephalopods have at command. Judging from its size, it would carry at least a barrel of this black liquid, if it had not been exhausted in some recent struggle."

"Is this mollusc a calmar?" asks the same writer. "If we might judge from the figure drawn by one of the officers of the *Alecton* during the struggle, and communicated by M. Berthelot, the animal had terminal fins, like the calmars; but it had eight equal arms, like the cuttle-fish. Now the calmars have ten, two of them being very long. Was this some intermediate species between the two? Or must we admit, with MM. Crosse and Fisher, that the animal had lost its more formidable tentacles in some recent combat?"*

Fig. 329.—Octopus vulgaris (Lamarck).

We now leave the section of the *Decapoda*, and commence the examination of the last two families of the Dibranchiate Cephalopods, which belong to the *Octopoda*.

The fifth family, *Octopodidæ*, contains *Eledone*, *Octopus*, *Pinnoctopus*, *Cirroteuthis*, *Philonexis*, and *Scærugus*, and contains Cephalopods having eight long arms, united at the base by a web; the suckers in two rows, which are sessile; the eyes fixed; shell, two short styles enclosed in the mantle; the body united to the head by a broad neck-band; no side fins. The body is oval, warty, and without fins in *Octopus* (Fig. 329). We have figured, as other species of the genus, *O. macropus* (Fig. 330), *O. brevipes* (Fig. 331), and *O. horridus* (Fig. 332); it is small and oblong, arms tapering and webbed, and suckers in a single row, in *Eledone*.

* The figure, Plate XXII., represents the animal with ten arms.

The two best-known species of this genus inhabit the Mediterranean. The one is *Eledone moschatus*, known in Italy under the

Fig. 330.—Octopus macropus (Risso).

Fig. 331.—Octopus brevipes (d'Orbigny).

name of Muscardino, from the strong odour of musk which it emits, even after death and desiccation; the other is *Eledone cirrhosus*, a small species, bluish-grey on the back, and whitish under the belly.

The habits of *Eledone moschatus* have been carefully studied by M. Verany. The able naturalist of Nice preserved many of these animals during a month, in a great aquarium, noting their habits. When in a state of tranquillity, the *Eledone* clung to the sides of the glass tank in which it was kept. Its head is then inclined forwards, with the body sac hanging behind; the funnel, turned upwards, presents the orifice between the arms. In this state the animal is yellowish in colour, its eyes dilated, its inspirations regular. But if irritated,

Fig. 332.—Octopus horridus (d'Orbigny).

a remarkable change takes place: its body assumes a fine maroon colour, and it is covered with numerous tubercles; the eye becomes contracted, a column of water is forcibly ejected from the funnel at the aggressor, and the respiration becomes precipitate, jerky, and irregular. The creature would take a strong inspiration, and, having collected its force, suddenly throw a jet of water to a distance of more than three feet. This state of passion, which the slightest touch is sufficient to produce, endures for half an hour or more. When it ceases, the animal resumes its form and primitive colours; but the least shock impressed on the water is sufficient to give it a deeper tint, which passes like a flash of lightning over the skin of this singular proteus.

The *Eledone* sleeps by day as well as by night, attaching itself during its sleep to the walls of its prison, leaving its arms to float around, the two inferior ones extending backwards, and the sac inclining over them; its eyes are then contracted, and in part covered by the eyelids. Its respiration is regular and slow, and any ejection of water very rare; its colour is then of a livid grey, and vinous red below, with whitish spots, while the brown spots have now entirely disappeared. While still asleep, it is watchful and attentive to all the dangers which could surprise it. The extremities of the arms floating round its body are ready to announce the approach or contact of any other object. Even the most delicate touch is perceived immediately, and it shrinks from the hand which seeks to approach it. Under every circumstance the *Eledone* exhales a strong odour of musk, which it preserves long after death.

When the *Eledone* swims, which it rarely does unless pressed by some urgent necessity, it carries the sac in advance, the arms floating behind—the six upper ones being on a horizontal line, the two others approaching each other below. Thus arranged, it presents, in consequence of its flattened form, a very large resisting surface to the water, its progress being due to the alternate dilatation and contraction of the body, which expels the water through the funnel, and by reaction produces a rapid and jerking movement. Sometimes the arms aid the movement; the eyes of the animal are then much dilated, and its colour a clear livid yellow, finely shaded with red, and covered with bright spots.

It is a singular fact that the creature notably changes colour under any exertion, so that the animal at rest and in motion are two different beings. When walking under water the funnel is directed behind, its arms are spread out, the head is raised, and the body slightly inclined forward; its mantle is then of a pearly grey, and

the spots take the tint of wine lees. When at rest the shades disappear.

In *Pinnoctopus cordiiformis*, a member of this family, the body is oblong, with lateral expansions, as represented in the accompanying figure (Fig. 333).

In *Cirrhotheutis* the arms are completely united in their whole extent by a thin membrane furnished with cirri, which alternate with certain suckers arranged in one row. Only one species (*C. Mülleri*)

Fig. 333.—Pinnoctopus cordiiformis (Q & G.).

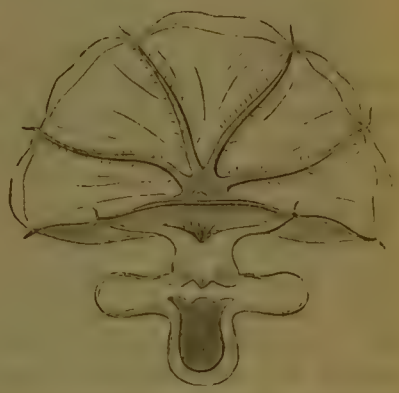


Fig. 334.—Cirrhotheutis Mülleri (Eschricht).

of this genera is known as an inhabitant of the northern seas, which is represented in Fig. 334.

The sixth family, *Argonautidæ*, contains only one genus, *Argonauta*.

Argonauta argus is the Paper Nautilus. Floating gracefully on the surface of the sea, trimming its tiny sail to the breeze, just sufficient to ruffle the surface of the waves, behold the exquisite living shallop! The elegant little bark which thus plays with the current is no work of human hands, but a child of Nature: it is the Argonaut, whose tribes, decked in a thousand brilliant shades of colour, are wanderers of the night in innumerable swarms on the ocean's surface!

The marine shell which Linnæus called the Argonaut enjoyed

great renown among the ancient Greeks and Romans. It was the subject of graceful legends; it had inspired great poets; it occupied the attention of Aristotle, who called it the *Nautilus* and *Nauticos*, and of Pliny, who called it *Pompylius*. Few animals, indeed, have been so celebrated, so anciently known. The Greek and Roman poets saw in it an elegant model of the ship which the skill and audacity of the man constructed who first braved the fury of the waves; in the words of the poet, "armour of triple oak and triple brass covered the heart of him who first confided himself in a frail bark to the relentless waves:"

> "Illi robur et æs triplex
> Circa pectus erat, qui fragilem truci
> Commisit pelago ratem
> Primus. . . . ."
>
> *Horace*, Car. I., iii. 9.

To meet the Pompylius was, according to the superstitious Roman, a favourable presage. This little oceanic wanderer, in spite of the capricious waves, was a tutelar divinity, who guarded the navigator in his course, and assured him of a happy passage. Listen to the immortal author of the first natural history of animals, the philosophical Aristotle. "The Nautilus Polyp," says the learned historian, "is of the nature of animals which pass for extraordinary, for it can float on the sea; it raises itself from the bottom of the water, the shell being reversed and empty, but when it reaches the surface it readjusts it. It has between the arms a species of tissue similar to that which unites the toes of web-footed birds. When there is a little wind, it employs this tissue as a sort of rudder, letting it fall into the water with the arms on each side. On the approach of the least danger it fills its shell with water, and sinks into the sea."

Pliny gives it the name of Pompylius, and, after the example of Aristotle, explains how it navigates, by elevating its two first arms, a membrane of extreme tenuity stretching between them, while it rows with the others, using its median arm as a rudder. The Greek poet, Oppian, who lived in the second century of our era, and to whom we are indebted for poems on fishing (*Helieutica*) and the chase (*Cynegetica*), says of it:—"Hiding itself in a concave shell, the Pompylius can walk on land, but can also rise to the surface of the water, the back of its shell upwards, for fear that it should be filled. The moment it is seen, it turns the shell, and navigates it like a skifull seamen: in order to do this, it throws out two of its feet like antennæ, between which is a thin membrane, which is extended by the wind like a sail, while two others, which touch the water, guide, as with a

rudder, the house, the ship, and the animal. If danger approaches, it folds up its antennæ, its sail, and its rudder, and dives, its weight being increased by the water which it causes to enter the shell. As we see a man who is victor in the public games, his head circled by a crown, while vast crowds press around, so the Pompylius have always a crowd of ships following in their track, the crews of which no longer dread to quit the land. O fish justly dear to navigators! thy presence announces winds soft and friendly: thou bringest the calm, and thou art the sign of it!"

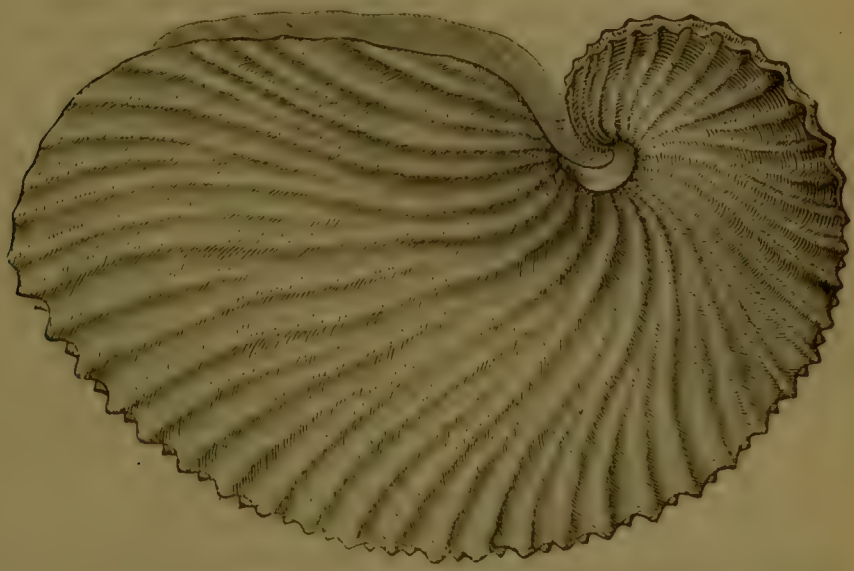


Fig. 335.—Shell of Argonauta argo (Linnæus).

Oppian carried his admiration a long way. That the Argonaut is an animated skiff is agreed on all hands; but, in making it almost a bird—in according to it at once the faculty of gracefully navigating the sea and floating in the atmosphere as an inhabitant of the regions of air—he was passing even the limits permissible to poetic license.

But the properties of the Argonaut have not alone struck the imagination of the Greeks and Romans; they also attracted the attention of the Chinese, who call it the boat-polyp. Rumphius informs us, that in India the shell (Fig. 335) fetches a great price. Women consider it a great, a magnificent ornament. In their solemn fêtes, dancers carry one of these shells in the right hand, holding it proudly above

their heads. Nor did it require the dithyrambic praises with which the ancients have surrounded it to recommend it to the admiration of modern naturalists. Without exaggerating the graceful attributes with which it is gifted, it is at once one of the most curious objects in Nature.

Its body (Fig. 336) is ovoid in form, and it is furnished with eight tentacles, covered with a double row of suckers. Of these tentacles, six are narrow and slender, tapering to a fine point towards the extremity, while the remaining two spread out in the form of wings or sails. These are all folded up when in a state of repose. The body itself is contained in a thin, white, and fragile univalve shell, which is oval, flattened on the exterior, but rolled up in a spiral in the interior, the last turn of the shell being so large as to give it something of the form of an elegantly-shaped shallop. Singularly enough, the body of the animal does not penetrate to the bottom of the shell, nor is it attached to it by any muscular ligament; nor is the shell moulded exactly upon it, as is the case with most other mollusca.

Fig. 336.—The Argonauta argo (Linnæus).

What does all this imply? Is the Argonaut a parasite, a fraudulent disinheritor, a vile assassin, who, having surprised and killed the legitimate proprietor of the shell, has installed itself in its place, and in the proper house of its victim? Such crimes are not without example in the natural history of animals—witness the proceedings of the curious *hermit crab*, whose proceedings we shall glance at in a future chapter. The parasitic character of the Nautilus was long believed in by naturalists; but recent facts have corrected this opinion. We have collected their shells, of all dimensions and of all ages, inhabited always by the same animal, whose size is always proportioned to the volume of the shell. More than that, it is now known that in the egg of the Argonaut the rudiments of the shell exist. M. Chenu tells us, that under the microscope Professor Duvernoy discovered a distinct shell contained in the embryo. Sir Everard

Home asserts the contrary; and no opportunity presented itself for the complete solution of the question, until Poli was placed by the King of Naples in a position to solve it. The piscina of Portici was placed at his disposal. He witnessed the curious mechanism by which the egg is expelled from the egg cavity, and found in it the rudiments of a shell, and satisfied himself, by following their development day by day, that the shell existed in the embryo, and grew with the animal. He satisfied himself also that the opinion enunciated by Aristotle, that at no point did the animal adhere to the shell, was perfectly true.

Finally, in the curious series of experiments carried on by Madame Power, in the port of Messina, the fragments of the frail bark of the mollusc, which were broken off in taking it, were restored in a few days, having been reproduced. It is, therefore, now quite demonstrated that the Argonaut, like other testaceous molluscs, itself secretes and constructs its shell—its diaphanous skiff. The reader, however, must not flatter himself that he can witness with his own eyes from the shore, in our narrow channel, the charming picture of the Argonaut painted by poets and natural historians: they never come near the shore. They are timid and cautious creatures, dwelling almost always in the open sea. They live in families, some hundreds of miles from the shore; and it is during the night, or at most in the fading light of sunset, that they assemble together to pursue their gambols on the surface of a tranquil sea.

However reluctant we may be to destroy the marvellous fictions of ancients and moderns, we are compelled to declare that there is no truth in the often-repeated statement that the Argonaut uses its palmated arms as oars or sails. In order to swim on the surface, it comports itself as all other Cephalopods do. It uses neither oars nor sails, and the palmate arms only serve to envelop and retain its hold on its frail shell. Its principal apparatus of progression is the funnel with which it is furnished, in common with all Cephalopods, and which is very long in the Argonaut. Aided by this apparatus, it ejects the water after it has served the purpose of respiration, and, in doing so, projects itself through the water. While it advances through the water under this impulse, its pendent arms, elongated and united in bundles, extend the whole length of the shell. Fig. 337 shows the position of the different parts of the animal when it thus breasts the waves. These arms are also powerful aids when the animal creeps on the ground at the bottom of the sea.

When the animal is disturbed it retires completely into its shell. From that moment, the equilibrium being changed, the shell is over-

turned, and the animal is nearly invisible. If frightened, it entirely submerges itself, and sinks to the bottom.

These little beings share with other Cephalopods the strange

Fig. 337.—Argonauta papyracea, as it swims by means of its locomotive tube.

faculty of changing colour under the influence of some vivid impression; but their graceful and delicate organisation redeems them from the charge we have brought against the cuttles. The Argonaut can blush, turn pale, and show through its transparent shell its body changing in sudden shades; but it never exhibits those bristling, unpleasant tubercles, the inheritance of the larger and coarser Cephalopods—the tyrants of the sea.

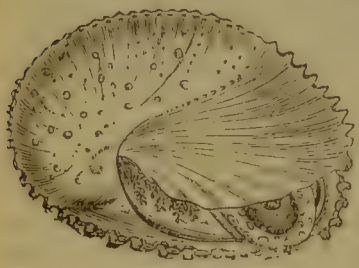


Fig. 338.
Argonauta papyracea in its shell.

The male Argonauts are very small, often not a tenth part of the size of the females, which alone possess the shells.

The female Argonaut carries its egg in the shell, and the little ones are also hatched in this floating cradle. Four or six species are at present known—the species described by Aristotle and Pliny, and the more ancient naturalists—namely, *A. argo*, or *papyracea* (Figs. 335 and 337), which are inhabitants of the Mediterranean as well as the Indian Ocean and the Antilles. Two others, *A. Owenii*, belonging exclusively to the Indian Ocean, and *A. hyans*, which is met occasionally in the Pacific and Atlantic Oceans.

THE DISTRIBUTION OF THE MOLLUSCA.

We have thought it better to treat this subject in a separate portion of this chapter, for its vast and complicated nature renders it otherwise difficult to handle, except in a space which would exceed the limits of this work.

The different genera of the Mollusca are peculiar to, or most frequent in, certain localities, and even species and varieties are known to have their peculiar limits. This fact pervades the entire range of organic beings, from the lowest plants to man. The geographical distribution of the Mollusca is perhaps that best known to science. The labours of Messrs. Louis Agassiz and R. M'Andrew, Dr. J. E. Gray, Professor Edward Forbes, and others, have done much towards giving us a clear idea of their distribution in space. Climate alone is insufficient to account for the distribution of animals: some higher cause rules here. But while we admit this, still we must acknowledge that climate exerts considerable influence in modifying species.

The distribution of the Mollusca may be considered from three points of view. First, as regards *space;* second, as regards *depth;* and third, as regards *time;* the last belongs to geology.

We shall now survey the principal divisions of the ocean; the line of demarcation being drawn, not by latitude or longitude, but by genera and species.

The Mollusca of the arctic seas are well known to show considerable analogy with those of the later Tertiary periods of Europe. Hence the great interest connected with their comparison, as it affords —provided we are satisfied with this line of argument—a proof that an arctic climate formerly existed in temperate regions. It is the northern Drift of which we are speaking. Even when species are found living in Britain identical with those of the arctic regions, still there is often a difference in the form or size of British and arctic specimens; certain species, such as *Cyprina Islandica*, being comparatively small in the south of Britain, larger in Shetland, and attaining their greatest size in Iceland.

The countries included in the arctic molluscan province are Lapland, Iceland, Greenland, the west coast of Davis' Straits, and Behring's Straits. About 200 species are enumerated by the various arctic voyagers, as found in these seas; of these about one-half are peculiar to them, and the other half are either found living in the temperate regions of Europe, or in their so-called glacial strata.

The Boreal province includes the North Atlantic, from Nova Scotia to Iceland, and from thence to Faroe, Shetland, and the Norway coast.

The number of species is very large; and more than one-half are common both to Scandinavia and the North American coast, while a great number also are found on the British coast.

The province called Celtic by Professor Edward Forbes embraces the coasts of Britain, Sweden, and Denmark.

Our British Mollusca are about 700 in number; those bearing shells are above 500. Of these about thirty are peculiar to Britain. The shells of the Baltic are identical with those of this province.

The Lusitanian province stretches from Madeira and the Canaries to the coasts of Spain and Portugal, and includes also the Mediterranean. But, as one might expect, on close examination the Mollusca in such a large area differ so widely that we are forced to admit the existence of great subdivisions.

The number of species found on the coast of Madeira by Mr. McAndrew was 156, of which forty-four per cent. were identical with British species, and eighty-three per cent. were common to the Canaries.

The shells of the Mediterranean are 600 in number; but it is probable that more extensive dredging will result in great accessions being made to this list. Nine genera are peculiar to the Mediterranean. A very small number of species only are identical with those now found in the Red Sea or the West Indies

In the character of its shells, the Black Sea resembles the Mediterranean, but does not contain much more than a tenth of the number of its species. The number of shells found on the Spanish and Portuguese coasts is much smaller than one would expect, and can only be attributed to the scanty explorations that have been made. As we might expect, the number of species identical with those of Northern Europe is much greater on the Atlantic than on the Mediterranean coast of Spain.

The sea of Aral, and the Caspian, contain a few peculiar species; but they have been so little explored, that it is premature, we think, to form them into a province. The proportion of salt contained in these seas is much less than in the ocean.

The west of Africa affords a considerable number of fine shells; the species most numerous being those of Murex, Conus, and Clavatula.

The South African province contains 400 species; the characteristic genera are Terebratella, Chiton, Patella, Trochus, Fissurella, Cypræa, and Conus. A large number of the species are not found elsewhere.

The Indo-Pacific province stretches from Australia to Japan, the greater part of the east coast of Africa, the Red Sea, Persian Gulf, the Asiatic coast, and the islands of the Indian Archipelago.

The Molluscs of the Red Sea remind us of those of India; the percentage of those found also in the Mediterranean being but small. The shells of the Persian Gulf are but little known; one species, the brindled cowry (*Cypræa princeps*), has been sold for £50

The seas of New Zealand and Australia have been formed into a province. As might be anticipated, their mollusca have little in common with those of the rest of the globe.

The Japonic province includes the coasts of Japan and the Corea.

The Aleutian province, the centre of which may be taken to be the Aleutian Islands, shows great analogy with the Boreal province of the west, a considerable number of the shells being identical—a fact especially interesting when we consider that very few species are found common to both the south-eastern and south-western coasts of America.

The Californian province is very distinct from that of Panama; the genera most numerous found there are Chiton, Acmæa, Fissurella, Trochus, and Purpura.

The marine shells of Panama are upwards of 1,300; the region included stretches from the Gulf of California to Peru. For our knowledge of this province we are much indebted to the researches of Dr. P. P. Carpenter, who has catalogued 654 species, as found at Mazatlan.

The Peruvian province contains a long list of species, and extends from Callao to Valparaiso.

The Magellanic province includes the extreme south of America and the Falkland Islands. Many genera, the species of which are usually small, here reach an enormous size, and afford, in many cases, the chief animal food consumed by the quadrupeds and human population of that wild and desolate coast.

The Patagonian province extends from St. Catharina to Point Melo on the east coast. The number of species found also in the Falkland Islands is very small; but a large number are identical with Brazilian species; yet the majority are peculiar.

The Caribbean province extends from Brazil to the West Indies, and includes also the northern coast of South America and the Gulf of Mexico; a total of 1,500 species is enumerated by Professor Adams as belonging to the province.

The Transatlantic province, or that on the coast of the United States, does not afford a large number of species, only 230 being known; of these only fifteen are found in Europe.

The study of the terrestrial and fresh-water mollusca affords even better grounds for their division into provinces; but we shall not enter into this subject here, as it belongs more especially to the Land World.

We shall now say a few words on the depth of the sea or ocean in which Mollusca are found.

The observations of Milne-Edwards, Audouin, and Professor Edward Forbes, have led to the division of the sea into four zones:—The deep sea Coral zone, from fifty to 100 fathoms; the Coralline zone from fifteen to fifty fathoms; the Laminarian zone, which stretches from fifteen fathoms to low water; and the Littoral zone, between high and low water marks.

The great stronghold of Crania, Thetis, Neæra, Yoldia, Dentalium, and Scissurella, is in the deep sea Coral zone; while Buccinum, Fusus, Pleurotoma, Natica, Aporrhais, Philine, and Velutina, which are among the most ravenous and predatory of molluscs, are found in the Coralline zone. They attack the bivalves, whose shells among the relics of former seas, as in those of the present, show evidence of assaults and murder.

The principal genera of the Laminarian zone are the different genera of the Nudibranchiata, and such genera as Aplysia, Trochus, Navicella, Rissoa, and Lacuna, which feed so much on the seaweed of this region.

The Littoral zone, which, being accessible as the tide recedes, is best known, affords Cardium, Mytilus, Tellina, Solen, Trochus, Patella, Littorina, and Purpura; or in plain English, cockles, mussels, razor-fish, limpets, periwinkles, and tingles—species which are the first to attract our attention, and which are so much used for food.

Nothing was known at the time of the translation of this work of the discoveries since made by Sars, Wyville Thomson, Pourtales, and others, as to what may now be well called the Deep Sea fauna which live in depths of from 100 to 1,500 fathoms.

CHAPTER XIX.

THE CRUSTACEA.

"Multa tamen lætus tristia pontus habet."—OVID.

WE divide the *Arthropods* into four classes, the *Insecta*, the *Myriapoda*, the *Arachnida*, and the *Crustacea*, and it is this last which must now engage our attention. It may, however, be proper to remark that we pass over here the large section of the ANNULOSA—animals, very many of which inhabit the sea; indeed, the classes *Annelida* and *Gephyrea* are almost exclusively marine.

The Crustacea is the lowest division of articulate animals; they possess feet; they breathe by means of gills, and have no tracheæ, or air-passages, as in the Insecta. The name signifies a hard crust or covering, with which the animals are protected. This consists of layers of carbonate of lime with one of pigment, generally, but not always, on the surface. The general outline of these animals is peculiar; unlike insects, they are not divisible into head, thorax, and abdomen; many species truly have no apparent head; but a pair of eyes point to the seat of intelligence. Most of these animals have two compound eyes; but a few, like some insects, have eyes both simple and compound. The mouth is situated in the under part of the anterior of the body: in some cases they have jaws, as in crabs; in other suckers only.

The Crustaceans have nearly all of them claws, formidably hooked and toothed, which they employ as pincers, both in offensive and defensive war. They have been compared to the heavily-armed knights of the middle ages—at once audacious and cruel; barbed in steel from head to foot, with visor and corslet, arm-pieces and thigh-pieces—scarcely anything, in fact, is wanting to complete the resemblance.

These marine marauders live on the sea-coast, among the rocks, and near the shore. Some few of them frequent the deep waters, others hide themselves in the sand or under stones, while the common crab (*Carcinus mœnas*, Leach) loves the shore almost as much as the

salt water, and establishes itself accordingly under some moist cliff overhanging the sea, where it can enjoy both.

One of the necessary consequences of the condition of these animals enclosed in a hard shell is their power of throwing it off. The solidity of their calcareous carapace would effectually prevent their growth, but at certain determinate periods Nature despoils the warrior of his cuirass, the creature moults, and the calcareous crust falls off, and leaves it with a thin, pale, and delicate skin. In this state the Crustacean is no longer worthy of its name—its skin has become as vulnerable as that of the softest mollusc; but it has the instinct of weakness, it retires into lonely places, and hides its weakness in some obscure crevice, until another vestment, more suitable for resistance, and adapted to its increased size, has been given to it.

The body of a Crustacean consists of a great number of distinct pieces, connected together by means of portions of the epidermis which have not yet become hardened, somewhat as the bones in the skeleton of the vertebrata are connected by cartilages, the ossification of which only takes place in old age. The body of the Crustacean consists of a series of segments varying in number, the normal number of the body-segments being twenty-one. Each segment is divisible into two arcs—one upper or dorsal, the other lower or ventral; and each arc may present four elementary pieces, two of which are united in the mesial line forming the *tergum*, or back; the lower arc is a counterpart of this, while the others form the two side or epimeral pieces. The skin, therefore, performs the functions of a skeleton, so that the Crustaceans—as was said by Geoffroy Saint Hilaire—like the molluscs, live inside and not outside their bony column. The analogue of the Crustacea amongst Vertebrata is to be found amongst Sturgeons, whose hard outer immovable bony case encloses a softer skeleton; these latter agree, however, in all their other characters with the higher divisions of the vertebrata, although their internal skeleton does not possess the solidity of bone.

The Crustaceans vary greatly in colour; some are of a dark iron grey with a dash of steel-blue, like metal weapons forged for combat; a few of them are red, or reddish-brown; others are of an earthy yellow or of a livid blue.

"The integument," according to Milne-Edwards, "consists of a *corium*, or true skin, and an epidermis, with pigmentary matter, which colours the former. The corium is a thick, spongy, and vascular membrane, connected with the serous substance which lines the parietal walls of the cavities, as the serous membrane lines the internal

cavities among the vertebrata." The pigment is less a membrane than an amorphous matter diffused through the outer layer of the superficial membrane, which changes to red in the greater number of species on being immersed in alcohol, ether, acids, or water at 212° Fahr.

The calcareous crust of the animal is thick, and in the dorsal region capable of great resistance; their arms and legs are also of remarkable hardness; but in the smaller species the shell is often thin, and of that crystalline transparency which permits of the functions of digestion and circulation being observed. Many species, which are quite microscopic, contribute colour to the sea—red, purple, or scarlet—such are *Grimothea Duperreii*, and *G. gregaria*.

Before the year 1823 it was not generally supposed that this class of animals was subject to change of shape in its larval condition, and during its progressive development; but about this time a certain able microscopist clearly demonstrated that a minute nondescript kind of animal, called the *Zoea Taurus*, was nothing more nor less than the young of a kind of Prawn that had just escaped from the egg. This able microscopist, Mr. Vaughan Thomson, of Cork, by many successive observations, and under the fire of much adverse criticism, satisfactorily established the truth of a metamorphic change taking place in many genera, and, in particular, in the common crab (*Cancer mœnas*); having succeeded in hatching the ova of this species, the product of which proved to be a true Zoea. That there are variations in this law of change has now been admitted, but that generally a metamorphosis exists analogous to that of insects in the various genera of Crustacea with hardly an exception has been clearly established.

The recorded observations of the eminent naturalist we have mentioned, Mr. Vaughan Thomson, as well as those of Mr. Couch, of Penzance, Professor Milne-Edwards—and particularly those of the last mentioned, who is the author of perhaps the best general work extant on the Crustacea—are referred to as treating in detail on this interesting subject.

As an illustration of this metamorphosis, we give figures of the *Zoea Taurus* in two states (Fig. 339), viz., *a*, in the first stage; and second, *b*, as the animal appeared on the fourth day after the first microscopical examination, and when it resolved itself into a kind of prawn. These drawings appear in Mr. Bell's "History of British Stalk-eyed Crustacea," and were taken by that gentleman from the work of a Dutch naturalist named Slabber, who made the original observation in the year 1768, and published the result in 1778, from which time the subject had been allowed to fall asleep until revived by Mr. Vaughan Thomson.

Among the Crustacea which have no neck the head gradually mingles with the thorax (*Cephalothorax*), but the abdomen remains distinct; the middle of the body is compressed. Among some Crustaceans there are neither thorax nor abdomen, nor head, but all

Fig. 339.—Zoëa Taurus.

three form only one mass, often short and squat, as in *Pisa tetraodon* (Fig. 340), the four-horned spider crab.

Many of these animals have the abdomen developed into a powerful tail, consisting of a certain number of altered segments, which it uses in swimming to force it through the water.

The Crustaceans, so far as they are aquatic, respire by means of *branchiæ*, or gills. In the larger species these branchiæ are in the form of lamellæ, which are traversed by two canals, one of which

leads the blood into the general body of the animals, the other directs it towards the heart. These organs are enclosed in the Cephalothorax. In some of the smaller species the branchiæ often appear exteriorly, hanging in the water like tassels. In some cases we find that the Crustacea have no special organs of respiration.

Nearly all the Crustaceans are strong, hardy, and destructive, forming a horde of nocturnal brigands—merciless marauders, who recoil from no trap in which they can lie in wait for their prey.

Fig. 340.—Pisa tetraodon.

They fight *à l'outrance* not only with their enemies, but often among themselves, either for a prey or for a female, sometimes for the sake of the fight. They struggle fiercely and audaciously with their claws. The carapace generally resists the most formidable blows; but the feet, the tail, and above all the antennæ, suffer frightful mutilation. Happily for the vanquished, the mutilated members sprout again after a few weeks of repose. This is the reason for the many Crustaceans met with having the claws of very unequal size: the smaller replace those lost in battle. Nature has willed that the Crustacean should not long remain an invalid. They soon return cured of their wounds. "We have seen lobsters," says Moquin-Tandon, "which have in an unfortunate encounter lost a limb, sick and debilitated,

reappear at the end of a few months with a perfect limb, vigorous, and ready for service. O Nature, how thou fillest our souls with astonishment and wonder!"

On the Spanish coast there is a species of crab known singularly enough by the name of *Boccaccio*. It is caught for its claw, which is considered excellent eating; this is taken off, and the mutilated animal is thrown into the sea, to be re-taken at some future time when the claw has reappeared.

Crustaceans are nearly all carnivorous, and eat eagerly all other animals, whether living or dead, fresh or decomposed. Little think they of the quality or condition of their food. It is amusing to witness the address and gravity with which the common crab, when it has seized an unfortunate mussel, holds the valve open with one claw, while with the other it rapidly detaches the animal, carrying each morsel to its mouth, as one might do with the hand, until the shell is entirely empty. The crab does not kill its prey directly, like the lobster; it swallows it, certainly, but with greater appreciation.

M. Charles Lespés surprised upon the shore at Royan a shoal of crabs at their repast. This day they seemed to have dined in common, and "God knows the enjoyment," as the good Fontaines said. They were in rows, every head turned to the same side, and nearly on end on their eight feet. They seized the small objects on the shore, which they carried to their mouths, each hand in its turn in regular order; when the right hand reached the mouth the left was on the ground. Only imagine a company of disciplined soldiers thus messing together at the same table!

The Long-horned Corophius (*Corophium longicorne*), remarkable for its long antennæ, knows perfectly well how to cut the byssus by which the mussels suspend themselves, in order that the bivalve may fall on the weeds among them. Other Crustaceans are also great oyster-eaters, and have the cunning or instinct to attack this mollusc without exposing themselves to danger. When the bivalve half opens its shell to enjoy the rays of the sun or take food, the evil-disposed Crustacean is romantically said to slip a stone between the valves; this done, it devours the poor inhabitant of the shell at its leisure.

The Corophii, respecting whom this assertion is hazarded, are extremely numerous on the shores of the Atlantic towards the end of summer and autumn. They make constant war upon certain marine worms. Off the coast of La Rochelle they may be seen in myriads beating the muddy bottom with their long antennæ in search of their prey. Sometimes they meet a Nereid or Arenicola many times their own size, when they unite in a body to attack it. In the oyster beds

of La Rochelle they are useful friends to the oyster by destroying these enemies, although they do not hesitate to attack the mollusc when it comes in their way. During the winter the mud of the *bouchots* gets piled up in unequal heaps, and when the warm season returns it has become hard and unfit for the cultivation of the mollusc. It is necessary to level and dry these mud-heaps—a process which would be both difficult and costly. Well, the Corophii charge themselves with the task. They plough up annually many square leagues covered with these heaps. They dilute the mud, which is carried out by the ebbing tide, and the surface of the bay is left smooth, as it was in the preceding autumn.

We have said that the Crustaceans do not even respect each other; the larger of the same species often devour the smaller. *Rara concordia fratrum!* Mr. Rymer Jones relates that he had on one occasion introduced six crabs (*Platycarcinus pagurus*) of different sizes into an aquarium. One of them, venturing towards the middle of the reservoir, was immediately accosted by another a little larger, which took it with its claws as it might have taken a biscuit, and set about breaking its shell, and so found a way to its flesh. It dug its crooked claws into it with voluptuous enjoyment, appearing to pay no attention to the anger and jealousy of another of its companions, which was still stronger and as cruel, and was advancing upon it. But, as Horace says—and he was not the first to say it—"There is nothing altogether happy"—

"Nihil est ab omni parte beatum."

Our ferocious Crustacean quietly continued its repast, when its companion seized it exactly as it had seized its prey, broke and tore it in the same fashion, penetrating to its middle, and tearing out its entrails in the same savage manner. In the meantime the victim, singularly enough, did not disturb itself for an instant, but continued to eat the first crab bit by bit, until it was itself entirely torn to pieces by its own executioner—a remarkable instance at once of insensibility to pain and of cruel infliction under the *lex talionis.* To eat and to be eaten seems to be one of the great laws of Nature.

Though essentially carnivorous, the Crustaceans sometimes feed on vegetable food. Many even seem to prefer fruit to animal food. Such is the robber-crab (*Birgus latro*) of the Polynesian Isles, which feeds almost exclusively on the cocoa-nut. This crab has one thick and strong claw; the others are comparatively slender and weak. At first glance it seems impossible that it could penetrate a thick cocoa-nut surrounded by a thick bed of fibre and protected by its strong

shell; but M. Liesk has often seen the operation. The crab begins by tearing off the fibre at the extremity where the fruit is, always choosing the right hand. When this is removed, it strikes it with its great claws until it has made an opening; then, by the aid of its slender claws, and by turning itself round, it extracts the whole substance of the nut.

The Crustaceans have eyes of two kinds, simple and compound: the first are sessile and immovable, and very convex; the others are borne on short calcareous stems or peduncles, and are formed of a number of small eyes symmetrically agglomerated together—the reunion of all the microscopic cornea of a composite eye—resembling in shape a cap formed of facets. It is said, for instance, that the eye of the lobster consists of 2,500 of these little facets. The simple eyes are short-sighted—the compound eyes are for more distant and perfect sight. They appear to have a strong sense of smell. Many of them cannot swim, but walk with more or less facility at the bottom of the water. It is said, for instance, that the cavalier of the Syrian coast, *Oxypoda cursor* (Fabricius), is named from the rapidity with which it traverses great distances.

The class Crustacea may be divided into seven orders:—1. The *Decapoda;* 2. the *Amphipoda;* 3. the *Isopoda;* 4. the *Xiphosura;* 5. the *Branchiopoda;* 6. the *Entomostraca;* and 7. the *Cirripedia.* The first of these orders is divided into three sub-orders:—*Macrura*, containing the Lobsters, Shrimps, and other long-tailed decapod Crustacea; *Anomoura*, containing the Hermit or Soldier-crabs; and the *Brachyura* or short-tailed crabs, such as the common edible crab. The second order contains the common Sand-hopper (*Talitrus locusta.*) Among the families of the third order we may mention that of the *Oniscidæ*, to which the very common Wood-louse belongs. The fourth order contains but a single genus, *Limulus.* One of the most remarkable species of this genus is the *L. Moluccanus*, the Molucca crab. It is distinguished by a long serrated spine or telson, which looks most formidable. They are in great request in the markets of Java. Linnæus thought that the fossil trilobites were closely allied to the *Limulus.* Latreille, on the contrary, classed them near *Chiton*, a genus of Mollusca. The body of *Limulus* so strikingly resembles that of many Trilobites, that the most common observers may perceive an affinity. The fifth order contains some very remarkable forms. We may specialise the genera *Apus*, *Daphnia*, and *Cypris;* and here also very probably belongs that family of extinct forms the Trilobites. The sixth order contains some non-parasitic forms, as *Cyclops;* it embraces a very large number of forms

found parasitic on fish, such as *Argulus*, *Chondracanthus*, *Lernea*, and *Penella*. The seventh and last order contains the strange and curious Acorn shells (*Balanus*), and Barnacles (*Lepas*), about which so many romantic and untrue stories have been published in the olden times.

To commence with the best known of these orders, the *Decapoda*, we find it containing the crabs and lobsters; these may be regarded as the chiefs or lords of the Crustacea. The crabs have very large claws, and often smooth backs; the lobsters have also large claws and the back sometimes covered with spines. Tiberius Cæsar had the face of a poor fisherman scratched by the rugged shell of a craw-fish.

Both crabs and lobsters are amazingly fecund, and lay an immense number of eggs, each female producing from 12,000 to 20,000 in the season. These eggs are, in the lobster, arranged in packets, which are attached to the appendages of the lower surface of the tail, to which they are connected by a viscous substance. The manner in which the female lobster disposes of her burden is curious and interesting. Whether she bends or stands erect she is able to hold it concealed or exposed to the light at will. Sometimes, according to Coste, the eggs are left immovable, or simply submerged; at others they are subjected to constant agitation by gently moving the false feet which contain them to and fro. When first extruded from the ovary the eggs are very small, but they seem to increase during the time they are borne about under the tail, and before they are committed to the sand or water they have attained the size of small shot. The evolution of the germ is in progress during six months. "As the young lie enclosed within the membrane of the egg," says Couch, "the claws are folded on each other, and the tail is flexed on them as far as the margin of the shield. The dorsal spine is bent backwards, and lies in contact with the dorsal shield, for the young when it escapes from the egg is quite soft, but it rapidly hardens and solidifies by the deposition of calcareous matter on what may be called its skin."

As soon as they are born the young Crustaceans withdraw from the mother and ascend to the surface of the water in order to gain the open sea. They swim in a circle; but their pelagic life is not of long duration; they quit it after their fourth moult, which takes place between the thirtieth and fortieth day, at which time they lose the transitory organs of natation which they have hitherto possessed. After this they are no longer able to maintain themselves on the surface, but drop to the bottom. Henceforth they are condemned to remain there, and such walking as they can exercise becomes their

Fig. 341.—Palinurus vulgaris. *a*, left outward foot-jaw.

habitual mode of progression. As they increase in size they gradually approach the shore, which they had for the moment abandoned, and return to the places inhabited by the parent Crustaceans.

The form of the larva differs so much from that of the adult, that it would be difficult, except on the clearest evidence, to determine the species from which they proceed. Former naturalists considered the embryo cray-fish (*Palinurus*) to belong to a distinct genus, which they designated *Phyllosoma*. It is now known, however, that these Phyllosoma are but the young of the higher forms of Crustacea undergoing metamorphosis. In the various forms of *Macrura* the metamorphosis is less decided than in the *Brachyura*. In the fresh-water cray-fish no marked metamorphosis whatever

Fig. 342.—Portunus variegatus, male.
a, external antenna; *b*, external foot-jaw; *c*, tail or abdomen.

takes place. Dissatisfied with the uncertainty of former experiments, Mr. Couch undertook a series of observations, which he has recorded in the proceedings of the Cornwall Polytechnic Society, in which he established the fact that a metamorphosis takes place in the following genera: *Cancer*, *Xantho*, *Pilumnus*, *Carcinus*, *Portunus*, *Maja*, *Galathea*, *Homarus*, and *Palinurus*. "Metamorphosis has been demonstrated," says Dr. Bell, "in no less than seventeen genera of the Brachyurous sub-order of Decapoda, in all which it is most decided and obvious; in *Leptopodia*, *Maja*, *Cancer*, *Portunus*, *Pinnotheres*, and *Grapsus*. In the Anomourous sub-order it is seen in *Pagurus*, *Porcellana*, and *Galathea*; and in the Macrourous sub-order in *Homarus*, *Palinurus*, *Palæmon*, and *Crangon*."

The swimming of these larval creatures is produced by contractions and expansions of the tail, and by repeated beating motions of the claws, the tail acting as a sort of vibratile oar, aided by which

Fig. 343.—Corystes Cassivelaunus, male.

they maintain themselves in the water and facilitate their progress. As the shell becomes more solid they get less active, and finally return to the bottom to cast their shell and assume a new form.

According to the observations of M. Coste, the young lobster casts its shell from eight to ten times in the first year, from five to

seven in the second, three to four times the third, and two or three times the fourth year. In the fifth year they attain the adult state. Whence it follows, that the small lobsters served at our tables have changed their calcareous vestment something like twenty-one times, and are now clothed in their twenty-second habit.

The species of crabs are numerous, and they vary in size. The

Fig. 344 —Corystes Cassivelaunus, female.

long-clawed crab (*Corystes Cassivelaunus*) of Pennant and Leach (Fig. 343) is remarkable for its long antennæ, which considerably exceed the body. The foot-jaws have their third joint longer than the second, terminating in an obtuse point, with a notch on its interior edge; eyes wide apart, borne upon large peduncles, which are short and nearly cylindrical; anterior feet large, equal, twice the length of the body, and nearly cylindrical in the males; in the females (Fig. 344) about the length of the body, and compressed, especially towards the hand-claw. The other feet terminate in an

elongated claw, which is straight-pointed and channeled longitudinally: the carapace oblong-oval, terminating in a rostrum anteriorly truncated and bordered posteriorly; the regions are but slightly indicated, with the exception of the caudal region, the branchial or thoracic regions being very much elongated.

Latreille gives the name of Corystes—which signifies a warrior armed—to this genus of short-tailed Decapod Crustacean, from κόρυς, a helmet. Pennant had already conferred the name of *Cassivelaunus*, the chief of the ancient Britons, for the singular reason, according to Gosse, that the carapace, which is marked by wrinkles, bears, in old males especially, the strongest and most ludicrous resemblance to the face of an ancient man, but surely Pennant's well-known sympathy with his British ancestry certainly never led him to caricature the grand old British warrior, as Mr. Gosse surmises. On the contrary, he saw in this Crustacean a creature armed at all points, and he named it after the hero of his imagination.

In this species the surface of the carapace is somewhat granulous, with two denticles between the eyes, and three sharp points directed forward on each side. The male has only five abdominal segments, but the vestiges of the separation of two others may be clearly remarked upon the outer mediate or third piece, which is the largest of all. The length of the antennæ is remarked on by Mr. Couch, in his "Cornish Fauna." "These organs," he says, "are of some use beyond their common office of feelers; perhaps, as in some other Crustaceans, they assist in the process of excavation; and when soiled by labour, I have seen the crab effect their cleaning by alternately bending the joints of their stalks, which stand conveniently angular for the purpose. Each of the long antennæ is thus drawn along the brush that fringes the internal face of the other, until both are cleared of every particle that adhered to them." On the other hand, Mr. Gosse suggests that the office of the antennæ is to keep a passage open for ejecting the deteriorated water after it has bathed and aërated the gills. "I have observed," he says, "that, when kept in an aquarium, these crabs are fond of sitting bolt upright, the antennæ placed close together, and pointing straight upwards from the head. This is doubtless the attitude in which the animal sits in its burrow, for the tips of the antennæ may often be seen just projecting from the sand. When the chosen seat has happened to be so close to the glass side of the tank as to bring the antennæ within the range of a pocket lens, I have minutely investigated these organs without disturbing the old warrior in his meditation. I saw on each occasion that a strong current of water was continuously pouring up

from the points of the antennæ. Tracing this to its origin, it became evident that it was produced by the rapid vibration of the foot-jaws drawing in the surrounding water, and pouring it off upwards *between the united antennæ*, as through a tube. Then, on examining these organs, I perceived that the form and arrangement of their bristles did indeed constitute each antennæ a semi-tube, so that when the pair were brought face to face the tube was complete."

Among the numerous genera of Brachyurous Crustaceans, *Grapsus* is distinguished by its less regularly quadrilateral form; the body nearly always compressed, and the sternal plastron but little or not at all curved backwards; the front strongly re-curved, or, rather, bent downwards; the orbits oval-shaped and of moderate size; the lateral edges of the carapace slightly curving and trenchant; the ocular pedicles large, but short: their insertion beneath the front and the cornea occupies one half of their length.

The Hermit or Soldier Crab (*Pagurus Bernhardus*, Fabricius, Fig. 337) is, perhaps, the oddest and most curious of anomourous Crustaceans. It differs from most other Crustaceans in this: that in place of having the body protected by a calcareous armour, more or less thick and solid, it has only a cuirass and head-piece to protect the head and breast; all the rest of the body is invested in a soft yielding skin; and this, the vulnerable part of the hermit crab, is the delicate morsel devoured by the gourmet. Nor is our somewhat soft-skinned Crustacean ignorant of the perfectly weak and defenceless state of its posterior quarters. Prudence or instinct makes it seek the shelter of some empty shell, of a shape and size corresponding to what it needs. When it fails to find one empty, it does not hesitate to attack some living mollusc, which it kills without pity or remorse, and takes possession of its habitation without other form or process. Once master of the shell (Fig. 345), it introduces itself, stern foremost, and installs itself as in an entrenchment, where it is established so firmly that it moves about with it more or less briskly, according to its comparative size.

The Soldier Crabs belong to the Anomourous family of Crustaceans, of which there are several genera, and a considerable number of species, the animal economy of which has been ably commented upon by Mr. Broderip. "Their backs," he says, "are placed towards the arch of the turbinated shell occupied by them, and their well-armed nippers and first two pairs of succeeding feet generally project beyond the mouth of it. The short feet rest upon the polished surface of the columella, and the outer surface of their termination, especially that of the first pair, is in some species

most admirably rough-shod, to give 'the soldier' a firm footing when he makes his sortie, or to add to the resistance of the crustaceous holders at the end of his abdomen or tail when he is attacked, and wishes to withdraw into his castle. On passing the finger down-

Fig. 345.—Pagurus Bernhardus. 1, out of the shell; *b*, in the shell; *a*, right foot-jaw.

wards over the terminations of these feet, they feel smooth; but if the finger be passed upwards, the roughness is instantly perceived. The same sort of structure (it is as rough as a file) is to be seen in the smaller caudal holders." In another species of Pagurus, from the Mauritius, which was nearly a foot in length, he found a great number of transverse rows, armed with acetabula, or suckers; these,

which must very much assist the hold of this species of *Pagurus*, were visible without the aid of a glass.

During feeding-time the hermit crab throws out his head and feet, and especially his great claws, and feels his way with his two antennæ, which are long and slender. When he walks he hooks on with his pincers to the nearest body, and draws his shell after him, as the snail does his. But the undefended parts of the body always remain under cover. At low water the hermit crabs spread themselves over the rocky shore, and the spectator thinks he sees a great number of shells which move in all directions, with movements different from that which belong to their essentially slow and measured race. If they are touched they stop suddenly, and it is soon discovered that their shell is the dwelling of a crustacean, not a mollusc. The animal lives alone in its little citadel, like the hermit in his cell or the sentinel in his box. Hence the names of *hermit* and *soldier*.

When our crustacean outgrows its borrowed habitation, it sets out in search of another shell a little larger and better suited for its increased size.

The hermit often avails itself, as we have said, of empty shells abandoned by their owners; when the tide retires these seldom fail them, and the hermit crab may be seen examining, turning, and returning, and even trying its new domicile. It glides slowly along on its abdomen, which is large and somewhat distorted, sometimes in one shell, sometimes in another, looking defiantly all round it, and returning very quickly to its ancient lodging if the new one does not turn out to be perfectly comfortable, often trying a great number, as a man might try many new suits of clothes before fitting himself. In its successive removals the little sybarite chooses a hermitage more and more spacious, according to its taste or caprice in colour or architecture. The cunning little creature chooses its mansion, now grey or yellow, now red or brown, globular or cylindrical, in the form of a spiral or of a tun, toothed or crenulate, with trenchant edge or pointed terminations; but, as a rule, our crustacean Diogenes houses itself in shells with spirals of considerable length, as in *Cerithium*, *Buccinum*, or *Murex*.

The hermit crab is very timid; at the least noise it shrinks into its shell, and squats itself down, without motion, drawing in its smaller claws and closing the door with its large one, the latter being often covered with hairs, tubercles, or with teeth. In short, our prudent cenobite clings so closely to the bottom of its retreat, that we might pull it to pieces without getting it out entire; its tail is transformed into a sort of sucker, by the aid of which it attaches

itself firmly to the walls of its habitation. It is at once strong and voracious, eating with much relish the dead fishes and fragments of molluscs and annelids which come in its way. Nor does it hesitate to attack and devour living animals. When introduced into an aquarium, it has sometimes thrown it into the utmost disorder by its insatiable rapacity. It has been possible sometimes to preserve harmony among many individuals inhabiting the same reservoir; but this has been owing rather to the impossibility of their attacking each other, in consequence of cunningly-devised barricades, than to their mildness of character or love of their neighbour. These animals, in short, are very quarrelsome. Two hermit crabs cannot meet without showing hostility; each extends his long pincers, and seems to try to touch the other, much as a spider does when it seeks to seize a fly on its most vulnerable side; but each finding the other armed in proof, and perfectly protected, though eager to fight, usually adopt the better part of valour, and prudently withdraws. They often have true passages of arms, nevertheless, in which claws are spread out and displayed in the most threatening manner; the two adversaries tumbling head over heels, and rolling one upon the other, but they get more frightened than hurt. Nevertheless, Mr. Gosse once witnessed a struggle which had a more tragic end. A hermit crab met a brother hermit pleasantly lodged in a shell much more spacious than his own. He seized it by the head with its powerful claws, tore it from its asylum with the speed of lightning, and took its place not less promptly, leaving the dispossessed unfortunate struggling on the sand in convulsions of agony. "Our battles," says Charles Bonnet, "have rarely such important objects in view; *they* fight each other for a house."

A pretty little Actinia, the Cloak Anemone (*Adamsia palliata*), loves to live with the hermit, and exhibits sympathies almost inexplicable. In the sea this anemone attaches itself almost always to the shell which serves as the dwelling of the Crustacean; and it may be looked upon as certain that where the hermit is there will the anemone be found. These two creatures seem to live in perfect and intelligent harmony together, for Mr. Gosse's observations establish the existence of a cordial and reciprocal affection between them. This learned and intelligent observer describes the proceedings of a hermit crab which required a new habitation; he saw it detach, in the most deliberate but effective manner, its dear companion, the anemone, from the old shell, transport it with every care and precaution, and place it comfortably upon the new shell, and then with its large pincers give to its well-beloved many little taps, as if to fix

it there the more quickly. Another species of Hermit Crab makes a companion of the *mantled anemone.* "And we are assured," says Moquin-Tandon, "that when the crab dies its inconsolable friend is not long in succumbing also."

"Is there not here much more than what our modern physiologists call automatic movements, the results of reflex sensorial action?" says Gosse. "The more I study the lower animals, the more firmly am I persuaded of the existence in them of psychical faculties, such as consciousness, intelligence, skill, and choice; and *that* even in those forms in which as yet no nervous centres have been detected."

As an article of food we think that the lobster far excels the crab; like the latter, they have an amazing fecundity, each female producing from 12,000 to 20,000 eggs in a season; and wisely is it so arranged, otherwise the consumption would soon exhaust the supply.

In France the size of the marketable lobster is regulated by law, and fixed at twenty centimètres (eight inches) in length; all under that size are contraband. Every year the inhabitants of Blainville proceed to Chaussy to fish for lobsters. They are taken in baskets in the form of a truncated cone, the mouth of which is so arranged that the animal can enter, but cannot get out. The numbers caught by each fisherman and his family in a season may be estimated at 1,000 or 1,200, which realise to the family 1,300 or 1,400 francs, the season lasting about nine months.

Lobsters are collected all round our own coast for the London market. On the Scottish shore they are collected and kept in perforated chests floating on the water, until they can be taken away to market. From the Sutherland coast alone 6,000 to 8,000 lobsters are collected in a season. This process goes on all round the coast, and as far as Norway, whence an enormous supply of the finest lobsters are obtained, for which something like £20,000 per annum is paid, all these contributions being conveyed to the Thames and Mersey in welled vessels. But these old-fashioned systems are being rapidly superseded by the construction of artificial storing ponds, or basins. Of these ponds Mr. Richard Scovell has erected one at Hamble, near Southampton, in which he can store with ease 50,000 lobsters, which will thus keep in good condition for six weeks. Mr. Scovell's tank is supplied from the coasts of France, Scotland, and Ireland, where fine lobsters abound. He employs three large and well-appointed smacks, each of which can carry from 5,000 to 10,000. On the west coast of Ireland alone, it is said, 10,000 fine lobsters a week might be taken.

The Lobster (*Homarus vulgaris*) is, indeed, found in great abundance all round our coast; frequenting the more rocky shores and clear water, where it is of no great depth, about the time of depositing its eggs. Various are the modes in which they are taken; cone-shaped traps made of wicker-work, and baited with garbage, are perhaps the most successful. These are sunk among the rocks, and marked by buoys. Sometimes nets are sunk, baited by the same material. In other places a wooden instrument, which acts like a pair of tongs, is used for their capture.

Mr. Pennant, the naturalist, paid great attention to the lobsters, and their habits are well described in a letter from Mr. Travis, of Scarborough. "The larger ones," he says, "are in their best season from the middle of October to the beginning of May. Many of the smaller ones, and some few of the larger individuals, are good all the summer. If they are four and a half inches long from the top of the head to the end of the back shell, they are called sizable lobsters; if under four inches, they are esteemed half size, and two of them are reckoned for one of size. Under four inches they are called pawks, and these are the best summer lobsters. The pincers of one of the lobster's large claws are furnished with knobs, while the other claw is always serrated. With the former it keeps firm hold of the stalks of submarine plants; with the latter it cuts its food very dexterously. The knobbed or thumb claw, as the fishermen call it, is sometimes on the left, sometimes on the right side, and it is more dangerous to seize it by the serrated claw than the other.

There is little doubt that up to a certain age the lobsters cast their shell annually, but the mode in which it is performed is not satisfactorily explained. It is supposed that the old shell is cast, and that the animal retires to some lurking-place till the new covering acquires consistence to contend with his armour-clad congeners. Others contend that the process is one of absorption, otherwise, if there were a period of moult, it would be shown by their shells. The most probable conjecture is that the shell sloughs off piecemeal, as it does in the cray-fish. The greatest mystery of all, perhaps, is the process by which the lobster withdraws the fleshy part of its claws from their calcareous covering. Fishermen say the lobster pines before casting its shell, and thus gets thin, so as to permit of withdrawing its members from it.

The female lobster does not seem to cast her shell the same year in which she deposits her ova, or, as the fishermen say, "is in berry." When the ova first appear under the tail, they are small and very black, but before they are ready for deposition they are almost as

large as ripe elderberries, and of a dark-brown colour. There does not seem to be any particular season for the laying of the eggs, as

Fig. 346.—Nephrops norvegicus.

females are found in berry at all seasons, but more commonly in winter. In this state they are found to be much exhausted, and by no means fit for the table.

The generic name *Astacus* (Fabricius), is now confined to the

crawfishes, which have a depressed rostrum, one tooth on each side, and the last ring of the thorax movable. The lobsters (*Homarus*) have the eyes spherical, the last ring of the thorax being soldered to the penultimate one. The Norway Lobsters (*Nephrops norvegicus*,

Fig. 347.—Crangon vulgaris. *a*, Anterior foot or claw.

Fig. 346) have the eyes uniform, and the two last rings of the thorax movable.

This last is one of the most beautiful of the larger Macrurans. Its general tint is pale flesh colour, with darker shades in parts, its pubescence light brown. This is generally considered a northern species; but Mr. Bell states that he has received specimens from the Mediterranean. It is found plentifully on the coast of Norway, on

the Scottish coast, and off the Bay of Dublin. It is considered the most delicate of all the Crustaceans.

Before concluding this chapter, we perhaps should not omit brief notices of the common prawn (*Palæmon serratus*) and the shrimp (*Crangon vulgaris*, Fig. 347) as types of the order Amphipoda. Species of this order are found to inhabit all seas, and many of them perform important functions as regards the sanitary state and economic condition of the waters of the ocean. These small animals are the scavengers of the sea—they pick up and devour all dead matter, leaving (it may be) a clean skeleton, without a shred of fibre behind. In this respect they resemble the ants on land, doing their work always thoroughly and effectively. We need hardly mention, what is so well known to every reader, that prawns and shrimps are amongst the most esteemed delicacies at our table, and as articles of food occupy no mean place on the fish-stall. It is hardly credible what immense quantities arrive at Billingsgate alone and are daily consumed in London and the neighbourhood by all classes of the community. The shrimp, which although the smaller crustacean, is perhaps the finest flavoured of the two, is sold in much larger quantities than its more aristocratic congener, the prawn. The fishery of these savoury comestibles gives occupation not only to regular able-bodied fishermen, who devote themselves to this branch, but also to large numbers of women and children, who, with their baskets and small nets, may be seen plying their vocation in a multitude of well-known localities on our coasts, especially on the southern and south-eastern shores. To the visitors of Hastings, Southampton, Bognor, &c., there is not a more picturesque or familiar marine picture than to behold a troop of little shrimpers, in their grotesque equipments, wading patiently knee deep, all in a row, as they push before them their pole nets.

Without giving a detailed technical and anatomical description, which our space will not permit of, we may observe that the common prawn (*Palæmon serratus*) is about four or five inches long, with a rounded carapace, which is jointed and furnished at the head with numerous long antennæ, the eyes being large and round. The tail is broad and flat, the caudal laminæ of which are furnished with long hairs on the terminal margins. The animal is also furnished with several pairs of feet, very slender, and ordinarily bent within themselves.

The colour is light grey, spotted and lined with purplish shades. In the water, however, prawns are almost transparent, from the nearly entire absence of carbonate of lime in the carapace; they are thus

very beautiful objects in the marine aquarium, moving as they do like shadows in the water.

When prawns are boiled, they become of a delicate pink colour, thus adding beauty to the dainty *morceaux*.

Like most other kinds of crustacea, the prawn is much larger in tropical climates. On the coast of South America, for instance, they attain a size of nine or ten inches in length, three of them being considered quite sufficient for a meal.

The London market is chiefly supplied with prawns from the Isle of Wight and the Hampshire coast.

Like the prawn, the shrimp has many varieties. The common shrimp (*Crangon vulgaris*) is about two and a half inches long from the eye to the extremity of the tail. It is also furnished with a rounded articulated carapace, with two antennæ. The eyes are prominent, marked, and near each other; the tail flat, laminated, and hirsute. The shrimp is not very unlike the prawn in general appearance, but is of a much less complex and finished structure. In colour it is greyish brown, clotted all over with dark brown.

This is one of the most abundant of all our coast crustaceans, swimming about and resting on the sands (which they closely resemble in colour) in immense shoals. Sometimes they are also found in eep water; but the margin of the sea is their favourite habitat. It may be added that large quantities of the smaller Palæmoniæd are caught with and sold as shrimps. Shrimps are in spawn all the year through, and cast their shells during the three months of spring.

CHAPTER XX.

FISHES.

BEFORE speaking of the habits of the principal kinds of fishes, it is desirable to glance very briefly at their organisation.

Fishes are intended to live always* in water, and this circumstance has impressed its mark upon their organisation; nevertheless, their forms are very varied. They are generally oblong and compressed laterally; they have no neck, the head being merely a prolongation of the trunk. In the majority of instances, the body is covered with scales, which may be described as thin bony substances, developed out of the skin and over-lapping each other like the tiles of a roof.

Nothing is more remarkable than the variety and brilliancy of colour in fishes; they present almost every gradation of colour, from gold or silver, and other dazzling colours, to the loveliest tints of blue, green, red, and black.

Fishes are essentially formed for swimming (Fig. 348), and all the different parts of their bodies are adapted for this purpose. The anterior limbs, which correspond with the arms in man and the wings in birds, are attached to each side of the trunk, immediately behind the head, and form the *pectoral fins*. The posterior limbs occupy the lower surface of the body, and form the *ventral fins*. The latter, which are always over the ventral line, may be placed before, beneath, or, as is most usual, behind the former. Fishes possess, besides these two pair of fins, odd fins. The fins which are found on the back or dorsum are called the back or *dorsal fins*, those at the end of the tail are the *caudal fins;* finally, there is frequently another attached to the lower extremity of the body, which is called the *anal fin*. These fins are always nearly of the same structure,

* The exceptions to these are the Doras, or flat-headed Hassars of India, which march overland in large droves; the Swampines of Carolina (*Hydrargyra*); and the *Perca scandens*, which in Tranquebar not merely walks over level ground, but climbs trees.

consisting generally of a fold of the skin, supported by slender, flexible, cartilaginous or osseous rays, connected by a thin membrane.

The muscles which bind together the vertebral column are so much developed in fishes, as well as others of the superior animals,

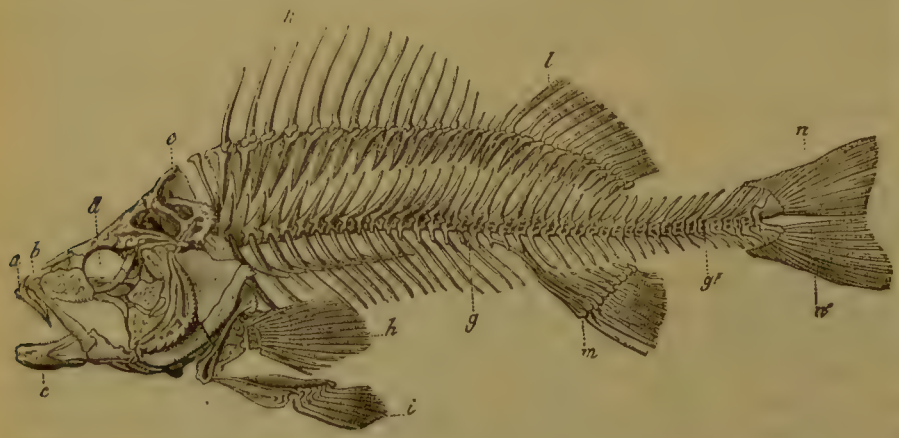


Fig. 348.—Skeleton of the Common Perch.
a, the inter-maxillary bone ; *b*, the maxillary bone ; *c*, the under jaw ; *d*, the palatine arch ; *e*, cranium ; *f*, the inter-operculum ; *g g*, the vertebral column ; *h*, the pectoral fin ; *i*, the ventral fin ; *k* and *l*, the dorsal fins ; *m*, the anal fin ; *n*, the caudal fin.

that they constitute in them alone the principal part of the body. The caudal, dorsal, and anal fins act as outlying oars ; the pectoral and ventral fins assist in progression, at the same time that they help to

Fig. 349.—Swimming bladder of the Carp.

maintain the equilibrium of the fish and guide and direct its movements, which are generally astonishing from their rapidity.

An organ, which is only met with in fishes, though not to be found in all species (Fig. 349), and which is usually considered as their chief aid in floating, is a large bladder situated within the body, between the dorsal spine and the abdomen ; this is usually called the *swimming bladder*. According to the volume this bladder

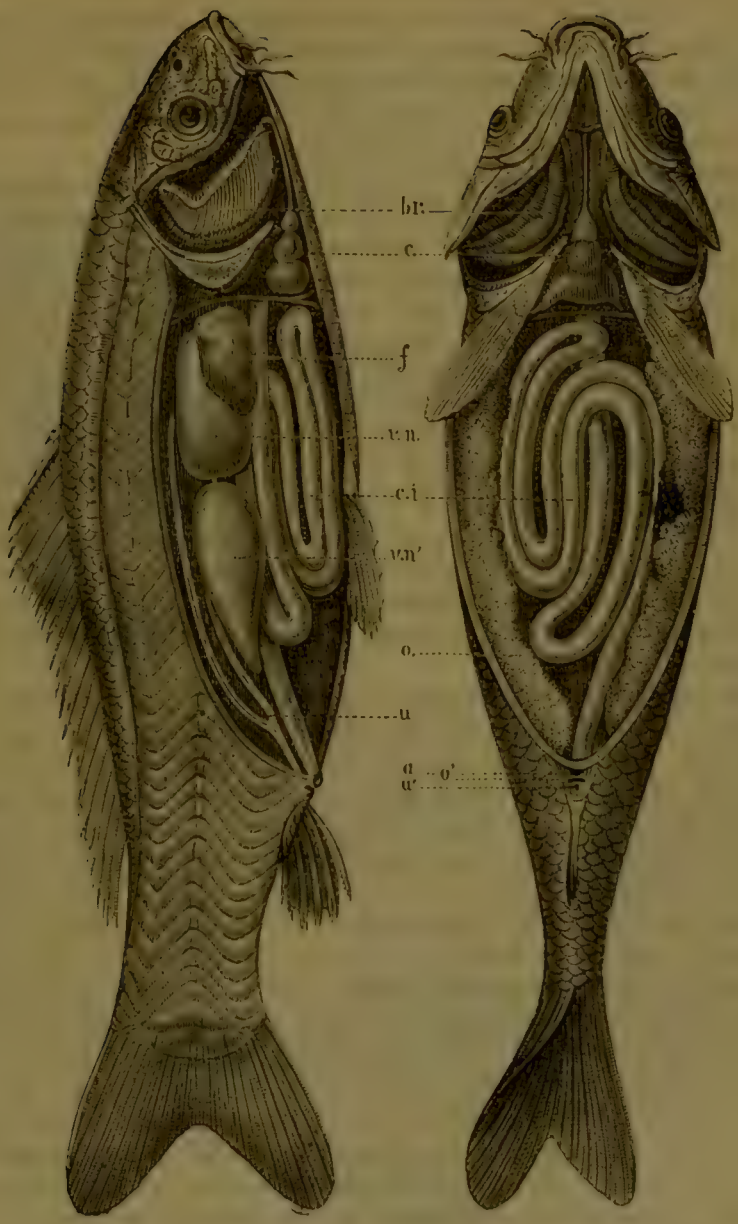


Fig. 350.—Anatomy of the Carp.

br, the branchiæ, or gill openings ; *c*, the heart ; *f*, the liver ; *vn*, swimming bladders ; *ci*, intestinal canal ; *o*, the ovaries ; *u*, urethra ; *a*, anus ; *o'*, oviduct.

assumes the animal can increase or diminish the specific gravity of its body; that is, it can remain in equilibrium or ascend or descend in the bosom of the waters; it is, moreover, remarked that it is very small in those species which swim at the bottom of the water, and, as Mr. Gosse says, there is some reason for considering it to be the first rudimentary form of the air-breathing lung.

Immediately behind the head two large openings are observed in most fishes; these are the gill openings. Their anterior edges are mobile, and are raised or lowered to serve the purposes of respiration; for here, in special cavities, are the gills, or branchiæ. These usually consist of many rows of thin membranous lamellæ, hung on slender arches of bone, placed on each side of the head, usually protected by bony plates, made up of several pieces, called the *gill-covers*. Respiration is effected by water taken in at the mouth, which passes over the gill-membranes, and is ejected through the margins of the gill-covers. During the contact of the water with the gills, the blood which circulates in these organs, and which communicates to them the red colour by which we recognise them, combines chemically with the oxygen of the air which the water holds in solution when it flows freely at the ordinary temperature in presence of the air. The blood is thus oxygenised, or made fit by respiration.

The heart in fishes is placed between the inferior parts of the branchial arches, and consists of a ventricle and an auricle (Fig. 350). It corresponds with the right half of the heart in the Mammals and Birds, for it receives the venous blood from all parts of the body and sends it to the gills. From this organ the blood is delivered into one great artery, which creeps along the vertebral column.

The eye in fishes is generally very large—we may even say enormous, relative to the size of the head—and is generally without true eyelids; the skin usually passes over the ocular globe, and becomes in front of it so transparent that the luminous rays can traverse it. This light covering is all the eyelid generally met with in fishes. The interior of the globe of the eye is covered by the membrane called *choroid*, the thin external fold of which, in consequence of the presence of innumerable microscopic crystals, often presents the appearance of a gold or silver-coloured coating, which gives to the iris that extraordinary brilliancy which belongs to the fish's eye. The crystalline lens is voluminous, spherical, and diaphanous. When the fish is cooked, the crystalline lens constitutes that opaque and hard white substance which is so often seen. Cuvier suspected,

what anglers now know to be true, that these active chasseurs of the deep saw far and very clearly.*

If fishes have great eyes, they have, on the other hand, very small ears. This organ, it is found, has no exterior opening. It forms a

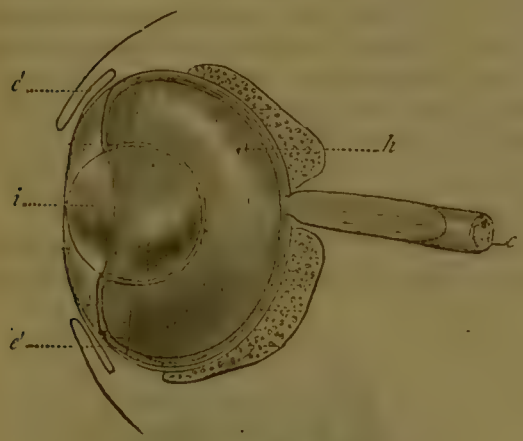


Fig. 351.—A Fish's Eye.
i, crystalline lens; *cc'*, cornea; *h*, posterior chamber; *c*, optic nerve.

Fig. 352.—Teeth of the Bream.

Fig. 353.—Teeth of the Carp.

cavity in the interior of the cranium, which is far from presenting the complicated structure of the ear in mammals and birds. In spite,

* Dr. Fripp's theory of the properties of the fish's eye is very plausible.

1st. That the fish's eye in its normal state is arranged for the vision of near objects, and that the great refractive power of a prolate spheroid lens, such as exists in the fish, is adequate to the production of a picture at short focal distances, even with rays of light passing through so dense a medium as water.

2nd. That there is no accommodation of the fish's eye for extended limits of vision.

3rd. That the passive state of the fish's eye, being that in which it is enabled to see objects near and at moderate distance, no active or physiological change for accommodation of sight for distant objects takes place or seems necessary.

The dioptric arrangement, being the reverse of that which obtains in animals where "accommodation" is observed, and in whom the *passive state* is that of vision, arranged for distant objects, while the *active state* is that of vision accommodated at will for near objects.

4th. That the vascular distribution of the choroid vessels has no relation to any movement of the lens, or change of its shape, but is arranged to meet the changes of static condition of the circulating fluid, and of dynamic force exerted by the heart under varying pressure from without; and that by such an arrangement, protection to the delicate tissues of the eye is afforded by a compensating balance between the tension of the blood within the vessels and the external pressure exerted upon them.

however, of the imperfect structure of their ears, fishes are sensible to the least noise. In consequence, silence is a rigorous law with fishermen.

The dimensions of the mouth and teeth are very variable in fishes; these organs are in proportion to their voracity, which in many of these beings is very great. The form and development of the buccal pieces are also very various. Some species are toothless, but in most fishes the teeth are very numerous. They are sometimes attached, not alone to the two jaws, but also to the palate, to the tongue, and upon the interior of the branchial arches, and even in the back mouth, that is to say, upon the pharyngeal portions, which surround the entrance to the œsophagus.

The form of their teeth is very variable, both in arrangement and position: some are in the form of an elongated cone, either straight

Fig. 354.—Teeth of the Trout.

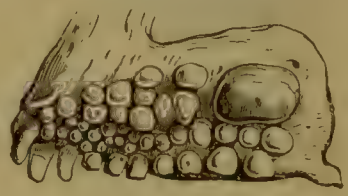


Fig. 355.—Teeth of the Gold-fish Dorada.

or curved. When small and numerous, they are comparable to the points of the cards used in carding wool or cotton. Sometimes they are so slender and dense as to resemble the piles of velvet, and often, from their very minute size, their presence is more easily ascertained by the finger than the eye. In some members of the Salmonidæ, for instance, we find a row of teeth on the bone that forms the middle ridge of the palate, which is called the *vomer*. On each side of this is another row on the *palatine* bones, and outside these is a third pair of rows on the upper jaw-bones. Some fishes have flat teeth, with a cutting edge in front of the jaws, like a true incisor; others have them rounded or oval, adapted to bruise or crush the various substances on which they feed.

The œsophagus, connected with the mouth, is short in fishes; the stomach and intestines vary in form and dimensions. Digestion is very rapid with these beings. Most of them feed on flesh, but there are a few where the mouth is without teeth, which feed on vegetables.

The growth of fishes is slow or very rapid, according to the abundance of food; they can suffer a very long fast, but in that state they

become diminutive in size, and finally perish of exhaustion. At certain seasons an irresistible impulse brings the two sexes together. Many species whose ordinary appearance is generally dull and unsightly now shine in the most brilliant colours. The female soon after lays her eggs, the number of which passes all imagination. Nature seems to have accumulated in the body of each female myriads of eggs—a wise provision, which is rendered necessary by the numerous causes of destruction which threaten them in their native element. The eggs, abandoned by the females to the mercy of the waves, are fecundated by the milt of the males, after being deposited. Such is a very brief summary of the organisation of fishes, which may be briefly described as vertebrate, cold-blooded animals, breathing by means of gills; living in water, moving through it by means of their fins, and reproducing their kind by means of eggs. And now a few words on their classification.

Fishes are naturally divided into two series, according to the composition of their internal skeleton. This is usually osseous; nevertheless, in a whole group of them the skeleton constantly retains the cartilaginous or fibro-cartilaginous state.

Professor Müller divides the fishes into five great orders. I. *Leptocardia*, II. *Cyclostomata*, III. *Selachia*, IV. *Ganoidea*, V. *Teleostea*. Agassiz's system of classification of fish, founded on the form of the scales, is perhaps better suited than this to the palæontologist, but the one given above, founded as it is principally on the anatomical peculiarities of fishes, is better suited to the zoologist. Agassiz's orders are *Ctenoid*, *Placoid*, *Ganoid*, and *Cycloid*.

I.—Leptocardia.

This order includes but a single genus, *Amphioxus*. *A. lanceolatus* is a little slender transparent fish, rarely attaining two inches in length. The vertebral column in it is represented by a gelatinous cord (*chorda dorsalis*). The mouth is quite destitute of jaws, and there is no trace of a true muscular heart. It is common on sandy coasts in various parts of the world.

II.—Cyclostomata.

The fishes of this order are characterised by the singular conformation of their mouth, which is formed for suction. The body is elongated, naked, and viscous, reminding us of serpents in their external form; they have neither pectoral nor ventral fins; the skeleton is cartilaginous, and consists of a dorsal cord and of a

rudimentary skull without any trace of true bony appendages. There are no jaws, but the inner surface of the mouth is often armed with teeth. Their gills, in place of presenting the comb-like appearance of other fishes, have something of the form of little sacs. The lampreys may be considered as the type of this family.

The Lampreys (*Petromyzon*) are cylindrical eel-like fish, with seven gill-openings on each side of the neck, forming two longitudinal lines; mouth round, armed with many teeth. The Sea Lamprey

Fig. 356.—The Lamprey (Petromyzon marinus).

P. marinus (Fig. 356), belongs to the Mediterranean; it is also found in the German Ocean, and is not rare along the coasts of Great Britain and Ireland. In the spring it ascends the rivers, where it is sometimes caught in abundance. Full-grown it is about three feet long, its colour is a marbled brown upon yellow; the dorsal fins are separated by long intervals; its mouth is circular and surrounded by a fleshy lip, furnished with cirri, having a cartilaginous plate for support; it is provided on its internal surface with many circular rows of strong teeth, some single, the others double.

The Lamprey feeds on worms, molluscs, and small fishes; its mouth is a powerful sucker, by the aid of which it attaches itself to rocks and stones under water. It is taken by hook and line, but is

much oftener speared by a sort of barbed harpoon, like the trident of the mythological Neptune, which is thrown javelin fashion at the animal when seen at the bottom of the water; the flesh is fat and delicate. In the twelfth century one of our kings, Henry I., surfeited himself at Elbeuf by partaking too largely of the Lamprey. The river-lamprey (*P. fluviatilis*) resembles the above in its general conformation, but is much smaller, and differs in the armature of the mouth, having only a single circular row of teeth. It is blackish above, silvery beneath, and is common in the markets of London and Paris. A smaller species, about ten inches in length, never leaves the fresh waters. It resembles the last species in colour, but its two dorsal fins are continuous; it is found in most European rivers and brooks. In some of the English rivers the river Lampreys are frequently taken in the eel-pots to the weight of two and three pounds each.

III.—Selachia.

The Selachians include a great number of cartilaginous fishes, varying much in form, including the rays, dog-fish, skate, torpedo, hammer-fish, sharks, and saw-fish; they have pectoral and ventral fins. The branchial arches are fixed, and the branchial sacs open into the pharynx by separate slits, and there are separate external apertures as well. These latter vary from five to seven on each side and in *Chimæra* there is but one. The young are often produced alive, while in some the ova are enclosed in remarkably horny egg-cases. Many of the Sharks have two spiracles on the upper part of their head. The order is divided into the Chimærina, the Raidina, and the Squalina.

Of the *Chimærina* we may mention the remarkable *Chimæra monstrosa*. The naturalists Clusius and Aldrovandus compared the fish to which this name is given to the chimæra, a monster of mythological antiquity, which is represented with the body of a goat, the head of a lion, the tail of a dragon, and a gaping throat which vomited flames. The strange form of this fish, the manner in which it moves, the peculiar shape of its snout, its mode of showing its teeth, its ape-like contortions and grimaces, its long tail, which acts with great rapidity, reminding one not a little of a reptile, are well calculated to strike the imagination. At a later period mediæval naturalists were contented to see in it a fish with a lion's head, and as the lion was then regarded as the king of animals, so the chimæra became the *herring king*.

The king of the herrings (Fig. 357) is from three to four feet in

length, of a general silvery colour, spotted with brown. It inhabits the North Sea, living on molluscs and crustaceans; occasionally, as if to justify the title which has been given it, levying heavy contributions upon the herrings. The *Callorhynchus Australis* is found in the southern hemisphere, and greatly resembles, in its appearance and habits, the northern species. In this species the end of the snout terminates in a cartilaginous appendage, which is bent backwards at the extremity, so as to acquire no small resemblance to a hoe.

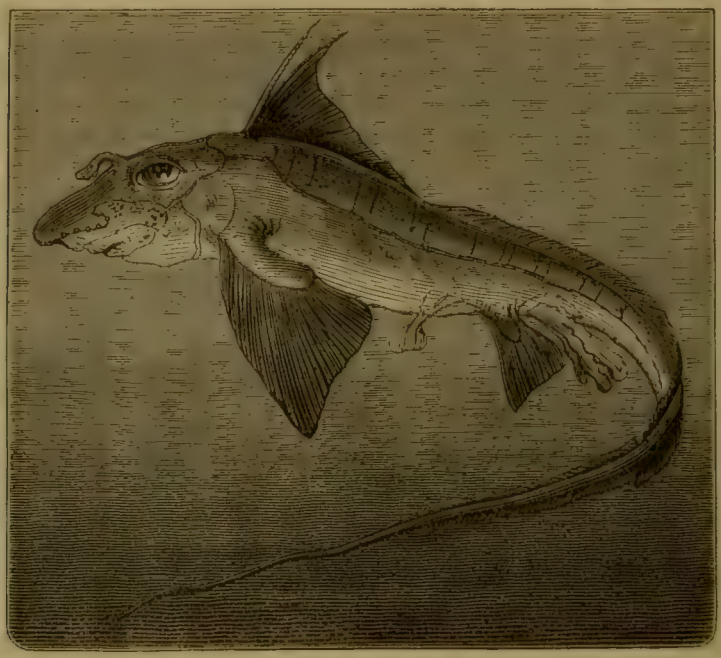


Fig. 357.—Chimæra monstrosa (the Arctic chimæra).

Of the RAIINA, if we regard them as a sub-order of the Selachia we would have at least half a dozen families. In *Cephalopteridæ* the head is truncated, with large, lateral eyes. In *Myliobatidæ* it is projecting, the pectoral fins extending like wings. In *Trygonidæ* it is enclosed by the pectorals. In the *Raiidæ* the body is rhomboidal, tail without spine, but with two small dorsals near the top. In the *Torpedinidæ* the body is nearly round, the tail short and fleshy, with two dorsals and a caudal fin. In *Rhinobatidæ* the head is prolonged into a sword-like organ, which is armed along its edges with strong tooth-like spines.

The White Ray, *Raia batis* (Fig. 358), reminds us of a lozenge, the point of the muzzle forming the lower angle, the longest ray of each pectoral forming the lateral angles, while the summit of the tail forms the last angle; the whole surface seems flat, but a swelling is distinguishable towards the head, on the upper surface, which bears,

Fig. 358.—The White Ray (Raia batis).

as it were, the contour of the body, properly so called, namely, the three cavities of the head, the throat, and the belly, which occupy the centre of the lozenge, beyond which the pectoral fins extend. These fins, though covered with a thick skin, permit the cartilaginous rays, with their articulations, to be very distinctly seen.

The head of the white ray, which terminates in a muzzle slightly pointed, is attached behind to the cavity of the breast. The mouth, placed in the lower part of the head and far from the extremity of the

muzzle, is elongated; its jaws are cartilaginous, and furnished with many rows of hooked and pointed teeth; the nostrils are placed in front of the mouth. The eyes, which open in the upper part of the head, are half projecting, and protected in part by a continuation of the soft, elastic, and retractile skin which covers the head. Immediately behind the eyes are two spiracles, which communicate with the

Fig. 359.—The Thornback (Raia clavata).

interior of the mouth. The animal is able to open and close these holes at pleasure, by means of an extensible membrane, which acts as a sort of valve. Through these holes it ejects the superabundant water beyond that which is necessary for respiration. In its general colour the animal is ashy grey on its upper surface; white with rows of black spots below.

Its tail is long, flexible, and slender, acting at once as a rudder and a weapon of offence or defence. When lying in ambush, nearly buried in mud at the bottom of the sea—and it has no desire to

change its position—a rapid and sudden stroke of this formidable weapon, armed with hooked spines on its upper surface, arrests its victim by wounding or killing it, without disturbing the mud or sea-weed by which it is covered. This species sometimes attains a very considerable size, and its flesh is firm and nourishing; but the larger specimens rarely approach inhabited shores, even when the female desires to lay her eggs. These eggs have a very singular shape, differing from almost every other fish, and particularly from those of all other cartilaginous fishes. They are quadrangular, a little flat, each of the four corners terminating in a small cylindrical beak, forming a kind of case formed of a strong and transparent membrane.

Fig. 360.—The Electric ray (Torpedo marmorata).

The Thornback, *R. clavata* (Fig. 359), so called in consequence of its armature, inhabits every European sea; sometimes it attains the length of twelve feet, and, being excellent eating, is much sought after by fishermen. It is frequently seen with the skate in European markets. A ray of great curving spines occupies the back and extends to the end of the tail; two similar spines are above, and two below the point of the muzzle. Two others are placed before, and three behind the eyes. Each side of the tail is furnished with a row of shorter spines; the whole surface, in short, bristles with larger or smaller spines, justifying the name of Thornback; for these are not given by way of ornament, but defence. The colour of the upper surface is generally brown, with whitish spots. The tail, which exceeds the body in length, presents towards the end two small dorsal fins, and terminates in a caudal fin.

Ray-fish of all kinds are inhabitants of the deep sea, but they change according to the seasons. While stormy weather prevails, they hide themselves in the depth of the ocean, where they lie in ambush, creeping along the bottom. But they do not always live at the bottom. They rise occasionally to the surface far from the shore, eagerly chasing other inhabitants of the deep, lashing the water with their formidable tails and fins, springing out of the water, and making it foam again under their gambols.

When pursuing their prey the rays employ their great pectoral fins, which resemble wings, and are aided by a very delicate and mobile tail; they beat the waters in order to fall unexpectedly upon their prey, as the eagle swoops down upon its victim. It may thus be called the king of fishes, as the eagle is the king of birds.

The family *Torpedinidæ* contains the genus Torpedo. The Electric Ray, *Torpedo marmorata* (Fig. 360), has considerable analogy with the Ray. Its flattened body forms a roundish disc, beyond which its rays form large pectoral fins; but the humeral girdle which carries them, carries also, in a great hollow, a most singular organic apparatus, which possesses the property of producing violent electrical commotions. This apparatus is placed in the interval between the end of the muzzle and the extremity of the fin, and completes the rounded disc of the body. The mouth is small, the slit crosswise; the jaws naked; the teeth in squares of five. The eyes are small; behind them are two star-like spiracles. On the lower or ventral surface there are two rows of small transverse slits, openings of the branchial sacs, like those of the rays. The tail is thick, short, and conical, carrying part of the ventral, and terminating in a sort of caudal fin. On the back are two small, soft, and adipose fins. The skin is smooth; the colour varies with the species; generally it is reddish-brown, with eye-like spots of a deep blue in the centre, sometimes azure, and surrounded by a great brownish circle, the spots being five or six. These curious fishes are found in the Channel and on the shores of the Mediterranean.

The electrical effects produced on the fisherman who seize them were noted from early times; but Redi, the Italian naturalist of the seventeenth century, was the first who studied them scientifically. He caught and landed one of them with every precaution. "I had scarcely touched and pressed it with my hand," says the Italian naturalist, "than I experienced a tingling sensation, which extended to my arms and shoulders, which was followed by a disagreeable trembling, with a painful and acute sensation in the elbow joint, which made me withdraw my arm immediately."

Réaumur also made some observations upon the Torpedo. "The benumbing influence," he says, "is very different from any similar sensation. All over the arm there is a commotion which it is impossible to describe, but which, so far as comparison can be made, resembles the sensation produced by striking the tender part of the elbow against a hard substance." Redi remarks, besides, that the pain and trembling sensation resulting from the touch diminishes as the death of the Torpedo approaches, and that it ceases altogether when the animal dies.

In the seventeenth century the fishermen affirmed that the sensation was even communicated through the line by which it was caught, and even by the water. Redi does not deny this phenomenon, neither does he confirm it. He states that the action of the animal is never more energetic than when it is strongly pressed by the hand, and makes violent efforts to escape. Neither Redi nor Réaumur, however, could explain the cause of the strange phenomenon. It was reserved for Dr. Walsh, a Fellow of the Royal Society of London, to demonstrate the fact that the power was electrical in its nature. This he did by numerous experiments which he made in the Isle of Ré. The following are some of his experiments.

He placed a living torpedo upon a clean wet towel; from a plate he suspended two pieces of brass wire by means of silken cord, which served to isolate them. Round the torpedo were eight persons, standing on isolating substances. One end of the brass wire was supported by the wet towel, the other end being placed in a basin full of water. The first person had a finger of one hand in this basin, and a finger of the other in a second basin, also full of water. The second person placed a finger of one hand in this second basin, and a finger of the other hand in a third basin. The third person did the same, and so on, until a complete chain was established between the eight persons and nine basins. Into the ninth basin the end of the second brass wire was plunged, while Dr. Walsh applied the other end to the back of the torpedo, thus establishing a complete conducting circle. At the moment when the experimenter touched the torpedo, the eight actors in the experiment felt a sudden shock, similar in all respects to that communicated by the shock of a Leyden jar, only less intense.

When the torpedo was placed on an isolated supporter, it communicated to many persons similarly placed from forty to fifty shocks in a minute and a half. Each effort made by the animal, in order to give them, was accompanied by the depression of its eyes, which were slightly projecting in their natural state, and seemed to be

drawn within their orbits, while the other parts of the body remained immovable.

If only one of the two organs of the torpedo is touched it happens that, in place of a strong and sudden shock, only a slight sensation is experienced—a numbness, or start, rather than a shock. The same result followed with every experiment tried. The animal was tried with a non-conducting rod, and no shock followed; glass, or a rod covered with wax, produced no effect; touched with a metallic wire, a violent shock followed. Melloni, Matteucci, Becquerel, and Breschet have all made the same experiments, with the same results; Matteucci having ascertained that the shock produced by the torpedo is comparable to that given by a voltaic pile of 100 to 150 pairs of plates.

The organ which produces this curious result is formed like a half-moon; it is double, and placed on each side of the head occupying the space between it and the base of the pectoral fins. It consists of a multitude of small prisms arranged parallel the one to the other and perpendicularly to the surface; 1,262 of these prisms have been counted in one of the two organs of a torpedo, three feet in length. Without entering into the anatomical descriptions which have been given by Stannius, Max Schultze, Breschet, and others, we may mention here that all the small parallelopipedes, which enter into its structure, are separated one from the other by walls of cellular tissue, in which are distributed the vessels and nerves. The nervous threads which each apparatus receives are divided into four principal trunks. According to modern authors, the electricity is elaborated in the brain under the influence of the will. It is afterwards transferred by means of the nervous threads into the principal organ, where it serves the purpose of charging the numerous little voltaic piles which constitute the organ of commotion.

It is, nevertheless, necessary to receive our comparisons of the apparatus of the torpedo with the voltaic pile of our laboratories with caution. The apparatus resembles a good conducting body, which is capable of being strongly electrified; it is sufficient to touch one of the surfaces in order to receive the shock. But if the little prisms composing it were charged like our voltaic piles, it would be necessary to touch both their surfaces in order to receive the shock. No perfect analogy can therefore exist between this natural apparatus and the scientific instrument named after Volta.

It is possible by the aid of heat to restore the extinct or suspended electrical functions of the torpedo. Retained in a tank of sea-water a yard in height by a third of that in diameter, and at 22° Centi-

grade in temperature, a torpedo preserved its faculties during five or six hours; another, which remained during ten hours in a very small quantity of sea-water at a temperature of 10° to 11° Cent., and which seemed dead, revived a little when placed in water at 20° Cent., and gave shocks during an hour. If held firmly by the tail, and pressed both above and below by a platinum rod to gather the true electricity, the animal contracts itself violently; but its movements are not always accompanied by electrical discharges, which demonstrates that the jets of electrical matter are not the result simply of the muscular contractions, but that they are subject to the will of the animal, and evidently given for resisting its enemies, and benumbing its prey. How wonderful and varied are the resources which Nature grants to her creatures in order to secure their existence!

The families of the sub-order Squalina are *Scyllidæ*, or Dog-fishes; *Carcharidæ*, or true Sharks; *Zygænidæ*, or Hammerheaded Sharks; *Lamindæ; Galeidæ; Cestraciontidæ; Spinacidæ;* and *Squatinidæ.* All the species have a lengthened body, merging into a thick tail, pectorals moderate in size, gill-openings on the sides of the neck, and not beneath the body, as in the Rays; eyes lateral.

Carcharidæ.—This family contains the true Sharks. Some species are said to attain the length of twenty and even thirty feet; but size is not their worst attribute; they have received, besides, strength and terrible teeth. Ferocious, voracious, impetuous, and insatiable, spread over almost every climate, inhabitants of every sea, and recently not seldom seen on our own shores, the sharks will rapidly pursue every fish, which fly at their approach; and threaten with their wide gullet the unfortunate victims of shipwreck, shutting them out from all hope of safety.

The body of the shark is long, and its skin is studded with small tubercles: this skin becomes so hard, and takes so high a polish, that it is employed in the preparation of various ornamental work. This dense resisting coat protects the shark from the bites of every inhabitant of the sea, if there be any daring enough to approach it with that view.

The back and sides of the White Shark, *Carcharius vulgaris* (Fig. 361), are of an ashy brown; beneath it is faded white. The head is flat, and terminates in a muzzle slightly rounded. Its terrible mouth is in the form of a semicircle, and of enormous size; the contour of the upper jaw of a shark of ten yards length being about two yards wide, and its throat being of a proportionate diameter to this monstrous opening. When the throat of the animal is open we see beyond the lips, which are straight and of the consistence of

leather, certain plates of teeth, which are triangular, dentate, and white as ivory. If the shark is an adult it has in the upper as in the lower jaw six rows of these murderous teeth, an arsenal ready to tear and rend its victim. These teeth take different motions according to the will of the animal, and are obedient to the muscles round their base, by means of which it can erect or retract its various rows of teeth; it can even erect a portion of any row, while the others remain at rest in their bed. Thus this far-seeing tyrant of the ocean knows how to measure the number and power of the arms necessary to destroy its prey: for the destruction of the weak and defenceless

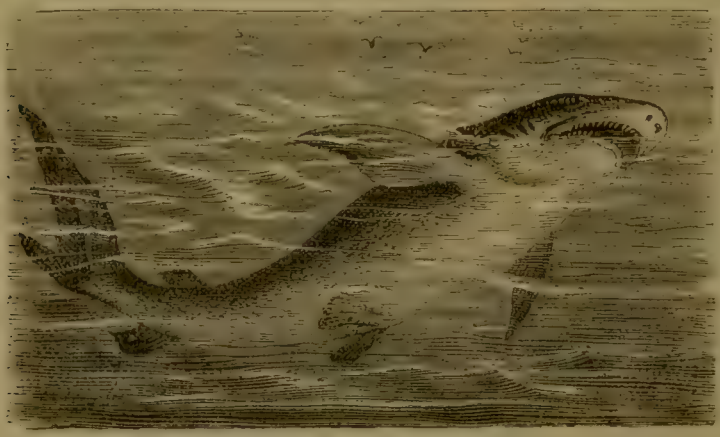


Fig. 361.—The Shark (Carcharius vulgaris).

one row of teeth suffices; for the more formidable adversary it has a whole arsenal at command.

The eyes of the shark are small, and nearly round; the iris of a deep green, the eyeball, enclosed in a transverse slit, is bluish. The scent of the white shark is said to be very subtle. Its fins are strong and rough. The pectoral fins are triangular, and much larger than the others, extending on each side, and giving powerful aid in swimming. The caudal fin is divided into two very unequal lobes, the upper extending in a sloping direction to twice the length of the other. This tail is possessed of immense power, and is capable of breaking the limb of a robust man by a single stroke.

During the hot season the male and female seek each other; they approach the coast roving in company, forgetting their ferocity for the time. The eggs are hatched at several periods in the ovary, from which the little ones issue two or three at a time.

The shark, as soon as born, becomes the scourge of the sea. He seizes all that comes near him. He eats the cuttle-fish, molluscs, and fishes, among others, flounders and cod-fish. But the prey which has the greatest charm for him is man; the shark loves him dearly, but it is with the affection of the gourmand. He even manifests, according to some authors, a preference for certain races. If we may believe some travellers, when several varieties of human food comes in its way, the shark prefers the European to the Asiatic, and both to the negro. Still, whatever may be the colour, he seeks eagerly for human flesh, and haunts the neighbourhood where he hopes to find the precious morsel. He follows the ship in which his instinct tells him it is to be found, and makes extraordinary efforts to reach it. He has been known to leap into a boat in order to seize the frightened fishermen; he throws himself upon the ship, cleaving the waves at full speed, to snap up some unhappy sailor who has shown himself beyond the bulwarks. He follows the course of the slaver, watching for the horrors of the middle passage, ready to engulf the negroes' corpses as they are thrown into the sea. Commerson relates a significant fact bearing on the subject. The corpse of a negro had been suspended from a yard-arm twenty feet above the level of the sea. A shark was seen to make many efforts to reach the body, and it finally succeeded in seizing it, member after member, undisturbed by the cries of the horror-stricken crew assembled on deck to witness the strange spectacle. In order that an animal so large and heavy should be able to throw itself to this height, the muscles of the tail and posterior parts of the body must have an astonishing power.

The mouth of the shark being placed in the lower part of the head, it becomes necessary for him to turn himself round in the water before he can seize the object which is placed above him. He meets with men bold enough to profit by this peculiarity, and chase him, formidable and ferocious though he is. On the African coast the negroes attack the shark in his own element, swimming towards him, and seizing the moment when he turns himself to rip up his belly with a sharp knife. This act of courage and audacity cannot, however, be said to be shark-fishing. The fishing operation is conducted as follows:—Choosing a dark night, the fisher prepares a hook by burying it in a piece of fat pork, and attaching it to a long and solid wire chain; the shark looks askance at this prey, feels it, then leaves it; he is tempted by withdrawing the bait, when he follows, and swallows it gluttonously. He now tries to sink into the water, but, checked by the chain, he struggles and fights. By-and-by he gets exhausted, and the chain is drawn up in such a manner as to raise the head out

of the water. Another cord is now thrown out, with a running knot or loop, in which the body of the shark is caught about the origin of the tail. Thus bound, the captured shark is soon hoisted on deck, as represented in PLATE XXIII. On the quarter-deck of the ship he is put to death, not without great precaution, however, for he is still a formidable foe, from his terrible bites, and from the still dangerous blows of his tail. Moreover, he dies hard, and long resists the most formidable wounds.

Captain Basil Hall gives a spirited sketch of the appearance and capture of one of these dreaded fishes—a capture in which the whole ship's company, captain, officers, young gentlemen inclusive, shout in triumphant exultation as the body of the shark flounders in impotent rage on poop or forecastle.

"The sharp-curved dorsal fin of a huge shark was seen rising about six inches above the water, and cutting the glazed surface of the sea by as fine a line as if a sickle had been drawn along it. 'Messenger, run to the cook for a piece of pork,' cried the captain, taking the command with as much glee as if an enemy's cruiser had been in sight. 'Where's your hook, quartermaster?' 'Here, sir, here,' cried the fellow, feeling the point, and declaring it was as sharp as any lady's needle, and in the next instant piercing it with a huge junk of pork weighing four or five pounds. The hook, which is as large as one's little finger, has a curvature about as large as a man's hand when half closed, and is six or eight inches in length, while a formidable line, furnished with three or four feet of chain attached to the end of the mizen topsail halyard, is now cast into the ship's wake.

"Sometimes the very instant the bait is cast over the stern the shark flies at it with such eagerness that he actually springs partially out of the water. This, however, is rare. On these occasions he gorges the bait, the hook, and a foot or two of the chain, without any mastication, and darts off with the treacherous prize with such prodigious velocity that it makes the rope crack again as soon as the coil is drawn out. Much dexterity is required in the hand which holds the line at this moment. A bungler is apt to be too precipitate, and jerk away the hook before it has got far enough into the shark's maw. The secret of the sport is to let the monster gulp down the whole bait, and then to give the line a violent pull, by which the barbed point buries itself in the coat of the stomach. When the hook is first fixed it spins out like the log line of a ship going twelve knots.

"The suddenness of the jerk with which the poor devil is brought

XXIII.—Shark Fishing.

up often turns him quite over. No sailor, however, thinks of hauling a shark on board merely by the rope fastened to the hook. To prevent the line breaking, the hook snapping, or the jaw being torn away, a running bowline is adopted. This noose is slipped down the rope and passed over the monster's head, and is made to join at the point of junction of the tail with the body; and now the first part of the fun is held to be completed. The vanquished enemy is easily drawn up over the taffrail, and flung on deck, to the delight of the crew."

The flesh of the shark is leathery, of bad taste, and difficult to digest. Nevertheless, the negroes of Guinea feed upon it, but not until it has been made tender and eatable by long preservation. In many parts of the Mediterranean coast small sharks are taken from their mother's belly and eaten. The under part of adult sharks is also eaten by the fishermen after the coarser parts have been removed. In Norway and Iceland this part of the animal is dried in the air during most part of the twelve months. The Icelanders also use the fat of the animal; the liver of one of them, according to Pontoppidan, will furnish a great quantity of oil.

We have thus, with the care it deserves, painted the portrait of the shark. The original is by no means beautiful; but, frightful as it may be, our description would be incomplete if we did not add that divine honours have been granted to this monster of the waters. Man worships force; he knows the hand which crushes, the teeth which rend. He respects the master or the king who strikes, and he venerates the shark. The inhabitants of several parts of the African coast worship the shark; they call it their *joujou*, and consider its stomach the road to heaven. Three or four times in the year they celebrate the festival of the shark, which is done in this wise:—They all row out in their boats to the middle of the river, where they invoke, with the strangest ceremonies, the protection of the great shark. They offer to him poultry and goats, in order to satisfy his sacred appetite. But this is nothing; an infant is every year sacrificed to the monster, which has been reared for the purpose from its birth; it is fêted and nourished for the sacrifice from its birth to the age of ten. On the day of the fête it is bound to a post on a sandy point at low water; as the tide rises, the child may utter cries of horror, but they are of no avail, it is abandoned to the waves, and the sharks arrive. The mother is not far off; perhaps she weeps, but she dries her tears, and thinks that her child has entered heaven through this horrible gate.

Of the family *Spinacidæ* there is no better known species than

that of the Picked Dog-fish, *Acanthias vulgaris* (Fig. 362), which sometimes attains the length of between three and four feet, and is exceedingly voracious. It feeds upon other fish, of which it destroys great quantities; it does not hesitate to attack even the fishermen, and especially bathers in the sea. It places itself in ambush, like the Rays, in order to attack its prey. The flesh of the Dog-fish is hard, smells of musk, and is rarely eaten; but the skin becomes an article of commerce, and is known as *shagrin*, being, like the skin of the

Fig. 362.—The Picked Dog-fish (Acanthias vulgaris).

shark, used for making spectacle-cases, and for other ornamental purposes, for which its green colour and high polish recommend it. There is a smaller species than the preceding, which haunts rocky shores, where it lies in wait for its prey. Its spots are larger and more scattered, and its ventral fins are nearly square. It feeds on molluscs, crustaceans, and small fishes.

The family *Zygænidæ* contains the strange Hammer-headed Shark, *Zygæna malleus* (Fig. 363), which is chiefly distinguished by the singular conformation of its head; it is flattened horizontally, truncate in front, and the sides prolonged transversely, giving it the appearance of the head of a hammer. The eyes of this fish are placed at the extremity of the lateral prolongations of the head; they are grey,

projecting, and the iris is gold-coloured. When the animal is irritated, the colours of the iris are said to become like flame.

Beneath the head and near to the junction of the trunk is the mouth, which is semicircular, and furnished on each jaw with three or four rows of large teeth, pointed and barbed on two sides.

The most common species in our seas is long and slender in the body, which is grey, the head blackish. It usually attains the length

Fig. 363.—The Hammerhead (Zygæna malleus).

of eleven or twelve feet, weighing occasionally nearly 500 lbs. Its boldness and voracity, and craving for blood, are even more remarkable than its size. If the hammerhead has not the strength of the shark, it surpasses it in fury; few fishes are better known to sailors, in consequence of its peculiarly-shaped head. Its voracity often brings it round ships, even in roadsteads and near the coast. Its visits impress themselves on the memory of the sailor, and he loves to relate his hairbreadth escapes from the meeting.

The family *Rhinobatidæ* contains the genus *Pristis antiquorum*, the Saw-fish, which is easily distinguished from all other known

fishes by the formidable weapon which it carries in its head. This weapon is a prolongation of the muzzle, which, in place of being rounded off or reduced to a point, forms a long, strong, straight sword-like termination, flat on both sides, but on the two edges it is furnished with numerous strong teeth of considerable length, which are prolongations of the hard, bony substance which forms the muzzle—forming, in short, a sword-blade deeply toothed on each edge.

Thus armed, the saw-fish, as it is sometimes called, the length of which is from twelve to fifteen feet, fearlessly attacks the most formidable inhabitants of the sea. With its threatening weapon, sometimes two yards in length, it dares to measure its strength even with the whale. All fishermen who visit the northern seas assert that the meeting of these ocean potentates is always followed by a combat of the most singular kind, in which the activity of the sword-fish is a match for the formidable strength of the whale. Occasionally it dashes itself with such force against the side of a ship, that its sword is broken in the timber. In the British Museum the blade of a sword-fish may be seen which was thus implanted in the timber of a ship.

IV.—Ganoidea.

In this order the gills are free and pectinated, as in the ordinary fishes. In the sturgeon the gill-openings present a single, very wide orifice, with an operculum. They are fishes of great size, living in the sea, but ascending the larger rivers in the spawning season. Our space only permits us to notice the Sturgeon, which belongs to the cartilaginous sub-order of the Ganoids; a second sub-order contains Ganoid fish with bony skeletons, such as the Bony Pike of the United States (*Lepidosteus osseus*).

The Sturgeons (*Acipenser*) are among the largest fishes known. Their muscles, however, are less firmly knit, their flesh more delicate, and their muscular strength is less than one would think from their great size; their mouths, instead of being armed with so many rows of teeth, are funnel-shaped and protrusible, and adapted for sucking up particles of food; they are not voracious, and their habits are not at all ferocious.

The Sturgeons are sea-fishes, periodically ascending and sojourning for a time in the larger rivers of Europe. They abound in the Black Sea and Sea of Azof, but they are chiefly known as frequenting the Volga and the Danube. The enormous consumption of caviare in Russia leads to a deadly pursuit of the common sturgeon

in all the great European rivers, and this species is in a fair way of disappearing altogether.

The Common Sturgeon, *Acipenser sterio* (Fig. 364), abounds in the North Sea and the Mediterranean, and occasionally it appears in the Thames, as well as here and there on the British coasts; in the Rhine, the Seine, the Loire, and the Gironde. It is usually from six to seven feet long, but has been known to attain the length of

Fig. 364.—The Common Sturgeon (Acipenser sturio).

nine or ten feet. Its general colour is yellow, with a white belly. It is rendered remarkable by the number and form of the osseous plates or scales, which cover the body like so many bucklers. Upon the back and belly are no less than twelve to fifteen of these rough bony plates, relieved by projections, which are pointed in the young, and are worn down with age. On each side is a row of thirty to thirty-five of these triangular ganoid plates, separated from each other by considerable intervals. The head is broad at the base, gradually contracting towards the point, and terminating in a conical muzzle. The mouth is large, and placed considerably behind the extremity of

the muzzle; and its jaws, in place of teeth, are furnished with cartilages. Between the mouth and the muzzle are a few slender and very elastic barbules. It is pretended that these barbules attract small fishes to the jaws of the animal, while it conceals itself among the roots of aquatic plants.

In the sea the sturgeon feeds on herrings, mackerel, and other fishes of moderate size. In the rivers it attacks the salmon, which ascend them about the same time. Mingling with them, however, it seems a giant. It deposits its eggs in great quantity. The roe of the female fish, when cleaned, washed in vinegar, and dried, is sold as caviare. Its flesh is delicate, and in countries where they are caught in quantities, it is dried and preserved. The rivers which enter the Black and Caspian Seas contain, besides the common sturgeon, many other species of the same genus, the flesh of which is even more delicate and *recherché* than the common sturgeon. Among the ancients this fish was held in unusual esteem. In Rome, in the time of the Emperors, we read of sturgeons borne in triumph to the sound of instruments, and laid upon tables fastidiously covered and decorated with flowers.

The Great Sturgeon (*Acipenser huso*), which sometimes exceeds 1,000 lbs. in weight, is only found in the rivers which flow into the Caspian and Black Seas, such as the Volga, the Don, and the Danube.

We are indebted to the Russian naturalist Pallas for the information we possess respecting the mode of taking the sturgeon in the Volga and other Asiatic rivers. Stakes are placed across the river, leaving just sufficient space between each pile to permit the animal to pass. Towards the centre this dike forms an angle opposed to the current, and, consequently, opposed to the fish which ascend the river towards the summit of this angle. At this point there is an opening which leads into a kind of enclosure, consisting of fillets towards the end of the winter and of osier hurdles during summer. The fishermen establish themselves upon a sort of scaffold, placed over the opening. When the fish are entangled in the reservoir, the men upon the scaffold drop a gate, which prevents their return to the sea. The movable bottom of the chamber is now raised, and the fishes easily taken, as represented in PLATE XXIV.

The fishermen are informed during the day of the approach of the sturgeons to the great enclosure by the movement they communicate to cords suspended to small floating substances in the water. During the night the sturgeons enter the enclosure, agitating by their movements other cords arranged round the hurdles. The agitation

XXIV.—Sturgeon Fishing on the Volga.

communicated to the cord is sufficient to shut the gates behind; they are thus imprisoned by the dropping of the gate, which in falling sounds a bell to wake the fisherman on the scaffold, should he be asleep. The sturgeon fisheries of the Volga are most admirably organised. Gmelin describes with some minuteness the sturgeon-fishing during the winter, in the caverns and hollows of the river-banks near Astrakhan, in the estuary of the Volga. A great number of fishermen are assembled there with their boats. The flotilla approaches the retreats to which the fishes have betaken themselves, the nets are skilfully arranged all round them, and all at once the whole mass of fishermen join in a great cry, at which the frightened fishes rush from their concealment and throw themselves into the nets spread for them.

The size of the fish, the nourishing properties of its flesh, its healthy and agreeable taste, and the immense quantity of eggs produced, have a wonderful power in exciting the commerce and industry of the inhabitants of these countries.

In order to give some idea of the abundance of the eggs of the sturgeon, it is stated that the weight of the roe in these fish will equal nearly a third of the weight of the whole animal; in other words, the roe would weigh nearly 800 lbs. in a female whose weight was 2,800 lbs. It is with these eggs that caviare is prepared; and the article is more or less relished according to the state of the eggs. The display of caviare, as exhibited at the Universal Exposition of Paris during the year 1867 will remain in the memory of those who visited it.

CHAPTER XXI.

V.—Teleostea, or Bony Fishes.

In this large order are many of the fishes which are most familiar to us. It is characterised, as we have said elsewhere, as a group of animals having a solid skeleton. It is divided into six sub-orders; these are: 1. *Plectognatha.* 2. *Lophobranchia.* 3. *Pharyngognatha.* 4. *Physostomata.* 5. *Anacanthina.* 6. *Acanthopterygea.* All these orders contain more or less familiar forms; the first, contains the great sun-fish, the globe-fish, and coffin-fish; the second, the pipe-fish and sea-horses; the third, the flying-fish and the wrasser; the fourth, the eels, herrings, salmon, carp, &c.; the fifth, the cod tribe and the flat-fish; and the sixth, the mullets, tunnies, gobies, perch, stickle-backs, and many others.

I.—Plectognatha.

From their organisation the fishes of this order seem to establish the passage from the *cartilaginous* to the *osseous* fishes. Their skeleton remains in a partly unossified condition. The bones of the head are, however, perfectly solid. The cranial and maxillary bones are firmly attached to the sides of the intermaxillary bones, and so form the jaw; the bones of the palate are united to the skull in such a manner as to be motionless. The opercula and rays of the gills are hidden under a thick skin, which leaves externally only small branchial slits. These fishes have no true ventral fin, and the pectoral fins are small and soft.

This sub-order comprehends two natural families, characterised by the armature of their jaws. They are the *Gymnodonta* and the *Sclerodermata.*

In the family of *Gymnodonta* the jaws have no apparent teeth, but they are covered with a plate of an ivory-like substance which represents them. The Sun-fish, *Orthagoriscus mola* (Fig. 365), belongs to this family.

The Sun-fish (*Orthagoriscus mola*), Fig. 365, greatly reduced in

size, is easily distinguished from any species of the genus *Tetraodon* by its compressed spineless body; being very round in its vertical contour, it has been compared to a disc, and more poetically to the sun—whence its popular name—to the great circular surface of which the dazzling silvery white disc bears some resemblance. But it is especially during the night that it justifies the name given to it. Then it shines brightly, from its own phosphorescent light, at a little distance beneath the surface. On very dark nights the sun-fish is sometimes seen swimming in the soft light which emanates from its body, the rays rendered undulating by the rippling of the water which it traverses, so as to resemble the trembling light of the sun half-veiled in misty vapours. When many of these fishes rove about together, mingling their silvery trains, the scene suggests the idea of dancing stars. The sun-fish is common on the west coast of Ireland, also in the Mediterranean, and it sometimes reaches the markets of Paris. It is from four to five feet in length, and its weight is considerable. Its flesh is fat and viscous, and by no means pleasant to eat.

Fig. 365.—Sun-fish (Orthagoriscus mola).

Fig. 366.—The Globe-fish (Tetraodon).

The species of the genus *Tetraodon* have a somewhat large head and bony salient jaws, which are each divided in front by a sort of vertical slit into two portions, which look like two teeth. These four portions of bony jaw, which project beyond the lips, somewhat resemble the hard and dentate jaws of the turtle. Their anterior part is sometimes prolonged, like the mandibles of the beak of the parrot. They are perfectly adapted to crush the shells of the molluscs, as well as the hard carapaces of the crustaceans, on which they feed.

The skin of these fishes bristles with small slightly-projecting spines, the number of which compensate for their smallness, which repel their enemies, and even wound the hand that would grasp them. They enjoy, besides, a singular faculty: they can inflate the lower portion of their body, and give it an extension so considerable that it becomes like an inflated ball, in which the real shape of the animal is lost. This result is obtained by the introduction of an immense quantity of air into the stomach when it wishes to ascend to the

Fig. 367.—Diodon pilosus.

surface. The species of globe-fish are numerous (Fig. 366). One is common in the Nile, where specimens are frequently left ashore during the annual inundations.

The species of *Diodon* (Fig. 367) differ from the sun-fish in the form of their bony jaws, each forming only one piece. They seem to have two teeth, whence their name, from δίς, *two*, ὀδοὺς, *teeth*. They differ also in their spines, which are larger. The fishes belonging to the genera *Tetraodon* and *Diodon* may be said to be the hedgehogs and porcupines of the sea.

There are many species of this genus—*Diodon pilosus*, represented in Fig. 367, will give an idea of the others.

The *Sclerodermata* are distinguished by their conical or pyramidal snout, terminating in a little mouth armed with true teeth; the skin is generally stiff and covered with hard scales. The File-fish, *Balistes*, and the Trunk-fish (*Ostracion*), are selected for notice. The File or Rudder-fish (Fig. 368) has the body compressed; the jaws are furnished with eight teeth, arranged in a single row on each jaw, and covered with true lips; the eyes are nearly level with the skin; the mouth is small, and the body enveloped in very hard scales, which

Fig. 368.—The File-fish (Balistes).

are connected in groups and distributed into compartments more or less regular, and strongly connected by means of a thick skin. The animal is thus protected by a sort of cuirass and casque very difficult to penetrate.

With the exception of one species, the genus *Balistes* inhabits the tropical seas. They are generally brilliantly coloured; they herd together in great numbers, and in their gambols produce curious combinations of brilliant colouring in the equatorial seas. Their flesh is held in slight estimation, and at certain periods of the year is even said to be dangerous.

The Trunk-fish, or Ostracion (Fig. 369), is without scales, but covered with regular osseous plates, which are so jointed the one to

the other that the body is, as it were, enclosed in a kind of box or long coffer, which only leaves the external organs of locomotion exposed, namely, the pectoral, dorsal, and caudal fins. In some the body is triangular, in others quadrangular, with or without spines.

Fig. 369.—The Trunk-fish (Ostracion).

These singular fishes are generally of moderate size, and are found only in the seas of warm climates.

II.—Lophobranchia.

The Lophobranchiate sub-order comprehends but few genera which are pretty numerous in species. Here the gills are formed of small round tufts, and arranged in pairs along the branchial arches—a structure quite peculiar, of which we have no examples in any other fishes. These gills are enclosed under a large cover, or operculum, attached on all sides by a membrane, which leaves only a small hole for the escape of water which has served the purposes of respiration.

Of these little cuirassed fishes the two best-known genera are *Syngnathus* and *Hippocampus*. The former, known as pipe-fishes, present a very curious snake-like outline. Their bodies are long, slender, and slightly tapering, covered with plates set lengthwise,

without ventral fins; the skin forms under the belly near the base of the tail, in some species, a pouch into which the eggs to be hatched are placed, and which is afterwards a shelter for the young. Most of the species are strangers to European seas, but some few are found around our coasts. The Pipe-fish, *S. acus* (Fig. 370), has the head small, the snout long, nearly cylindrical, slightly raised at the end, and terminating in a very small mouth without teeth. The animal is about twenty inches long; its skin is of a yellowish colour varied

Fig. 370.—The Pipe-fish (Syngnathus acus).

with brown. It lives in both the Atlantic and Mediterranean seas, where it is largely used by the fishermen in baiting their hooks.

The Sea Horse (*Hippocampus brevirostris*) is a small creature about the size of the engraving (Fig. 371); its head has a singular resemblance to that of the horse. The rings which form the integument of the body and tail have a close resemblance to the rings of some caterpillars. This curious combination of forms originated the name Hippocampus, from ἵππος, *horse*, κάμπος, *fish*, adopted in very ancient times to designate this creature. It is found in the Atlantic, round the coast of Spain, the south of France, on the coast of Britain, in the Mediterranean, and in the Indian Ocean. Mr. Lukis, who observed two females in captivity, describes their habits as

follows:—"When they swim," he says, "they preserve a vertical position, but their tail seems on the alert to seize whatever it meets with in the water, clasping the stem of the sea-weeds. Once fixed, the animal seems to watch attentively all the surrounding objects, and darts on any prey presenting itself with great dexterity. When one of them approaches the other, they interlace their two tails, and it is only after a struggle that they can separate again, attaching

Fig. 371.—The Sea-horse (Hippocampus brevirostris).

themselves by the lower part of the chin to some weed in order to release themselves. They have recourse to the same manœuvre when they wish to raise the body, or when they wish to wind their tail round some new object. Their two eyes seem to move independently of each other, like those of the chameleon. The iris is bright and edged with blue."

The sea-horses have the pectoral fins so formed as easily to sustain the body in the water; they are, in fact, winged fishes, and probably originated the famous winged courser of mythology, after which they are sometimes named. They rarely exceed four inches in

length; the body is covered with triangular scales, commonly of a bluish colour. They live on worms, fishes' eggs, and fragments of organic substances which they find at the bottom of the sea.

III.—Pharyngognatha.

This order contains fishes in which the inferior pharyngeal bones are so completely coalescent as to form a single bone, which is usually armed with teeth. Professor Müller divides this sub-order into two groups, that in which the fins are partially spinous (*Acanthopterygii*), and that in which the fins are soft (*Malacopterygii*). Of this latter group we have one interesting family, that of the *Scomberesocidæ*, to which the genus *Exocœtus* belongs.

Flying is so much associated in our minds with the usual denizens of the air, that the idea of flying-fishes seems to be a contradiction. Nevertheless, some fishes possess that power, the fins being transformed into wings, which they are enabled to raise for a few seconds. These wings, however, are neither long nor powerful, for they rather act the part of a parachute than wings. The distinguishing characteristic of the *Exocœtus*, or flying-fish, is its pectoral fins, which are nearly the length of the body, the head is flattened above and on the sides, the lower part of the body furnished with a longitudinal series of carinated scales on each side, the dorsal fin placed above the anal, the eyes large, and the jaws furnished with small pointed teeth.

The flying-fishes (Fig. 372) in their own element are harassed by attacks of other inhabitants of the ocean, and when, under the excitement of fear, they take to the air, they are equally exposed to the attacks of aquatic birds, especially the various species of gulls. We have said that in their leap from the water their fins sustain them rather as parachutes than wings, with which they beat the air. Mr. Bennett's description is pretty clear on this point. "I have never," he says, "been able to see any percussion of the pectoral fins during flight; and the greatest length of time I have seen this volatile fish on the fly has been thirty seconds by the watch, and the longest flight, mentioned by Captain Basil Hall, has been 200 yards, but he thinks that subsequent observation has extended the space. The usual height of their flight, as seen above the surface of the water, is from two to three feet; but I have known them come on board at the height of fourteen feet and upwards; and they have been well ascertained to come into the chains of a line-of-battle ship, which is considered to be upwards of twenty feet. But it must not be supposed that they have the power of raising themselves into the air after

having left their native element; for on watching them I have often seen them fall much below the elevation at which they first rose from the water; nor have I ever in any instance seen them rise from the height to which they first sprang, for I conceive the elevation they take depends on the power of the first spring.

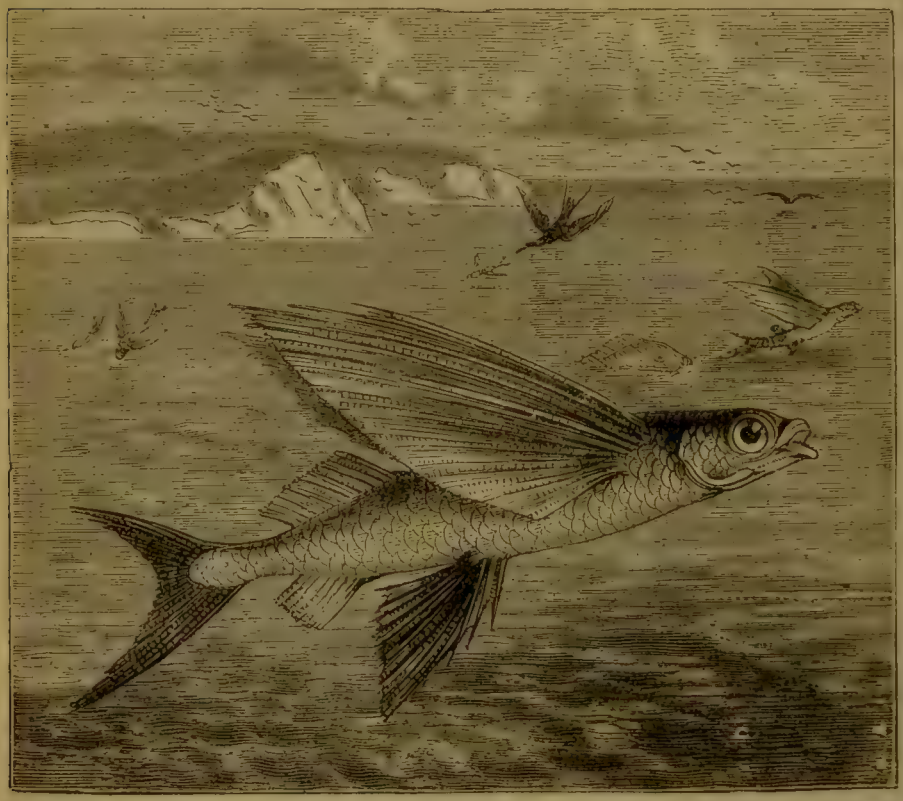


Fig. 372.—The Flying-fish (E. exiliens).

The most common species is *E. volitans*. Its brilliant colouring would seem designed to point it out to its enemies, against whom it is totally defenceless. A dazzling silvery splendour pervades its surface. The summit of its head, its back, and its sides, are of azure blue; this blue becomes spotted upon the dorsal fin, the pectoral fin, and the tail. This fish is the common prey of the sea-birds and the more voracious fishes, such as the shark; its enemies abound in the air and water. If it succeeds in escaping the Charybdis of the

water, the chances are in favour of its meeting its fate in the Scylla of the atmosphere; if it escapes the jaws of the shark, it will probably fall to the share of the sea-gull. The dolphin is also a formidable enemy to the much-persecuted flying-fish. Captain Basil Hall gives a very animated description of their mode of attack.* He was in a prize, a low Spanish schooner, rising not above two feet and half out of the water. "Two or three dolphins had ranged past the ship in all their beauty. The ship in her progress through the water had put up a shoal of these little things (flying-fish), which took their flight to windward. A large dolphin, which had been keeping company with us abreast of the weather gangway at the depth of two or three fathoms, and, as usual, glistening most beautifully in the sun, no sooner detected our poor dear friends take wing than he turned his head towards them, darted to the surface, and leaped from the water with a velocity little short, as it seemed to us, of a cannon-ball. But though the impetus with which he shot himself into the air gave him an initial velocity greatly exceeding that of the flying-fish, the start which his fated prey had got enabled them to keep ahead of him for a considerable time. The length of the dolphin's first spring could not be less than ten yards, and after he fell we could see him gliding like lightning through the water for a moment, when he again rose, and shot upwards with considerably greater velocity than at first, and of course to a still greater distance. In this manner the merciless pursuer seemed to stride along the sea with fearful rapidity, while his brilliant coat sparkled and flashed in the sun quite splendidly. As he fell headlong in the water at the end of each leap, a series of circles were sent far over the surface, for the breeze—just enough to keep the royals and topgallant studding-sails extended—was hardly felt as yet below.

"The group of wretched flying-fishes, thus hotly pursued, at length dropped into the sea; but we were rejoiced to observe that they merely touched the top of the swell, and instantly set off again in a fresh and even more vigorous flight. It was particularly interesting to observe that the direction they took now was quite different from the one in which they had set out, implying but too obviously that they had detected their fierce enemy, who was following them with giant steps along the waves, and was gaining rapidly upon them. His pace, indeed, was two or three times as swift as theirs, poor little things! and the greedy dolphin was fully as quick-sighted; for whenever they varied their flight in the smallest degree,

* "Lieutenant and Commander." By Captain Basil Hall. Bell & Daldy, London.

he lost not the tenth part of a second in shaping his course so as to cut off the chase; while they, in a manner really not unlike that of the hare, doubled more than once upon their pursuer. But it was soon plainly to be seen that the strength and confidence of the flying-fish were fast ebbing; their flights became shorter and shorter, and their course more fluttering and uncertain, while the leaps of the dolphin seemed to grow more vigorous at each bound. Eventually this skilful sea-sportsman seemed to arrange his springs so as to fall just

Fig. 373.—Stomias boa.

under the very spot on which the exhausted flying-fish were about to drop. This catastrophe took place at too great a distance for us to see from the deck what happened; but on our mounting high on the rigging, we may be said to have been in at the death; for then we could discover that the unfortunate little creatures, one after another, either popped right into the dolphin's jaws as they lighted on the water, or were snapped up instantly after."

Esocidæ.—This family contains the well-known fresh-water Pike and also the marine genus *Belone*, to which the gar fish belongs, and the strange genus *Stomias*. Here the body is much elongated, the muzzle being very short, the mouth very deeply cleft, the opercula reduced to small membranous lamina; the intermaxillary palatine

and maxillary bones are rather sparingly furnished with teeth, and these are long and hooked. Similar teeth are observable on the tongue. The ventral fins are placed far back, and the dorsal fin is placed opposite the anal fin, on the hinder extremity of the body.

Only two species of this genus are known: the one of the

Fig. 374.—Adult Green and Red varieties of Labrus communis.

Mediterranean, *Stomias boa* (Fig. 378), the other of the Atlantic Ocean, *S. barbatus*, so called from the long barbula on the chin. Both species are black in colour, with numerous small silvery spots on the abdomen. The body of *S. boa* is thin, compressed, covered with little thin scales of blackish blue, much spotted on the back and abdomen, a little brighter on the sides; the head, in some respects, recalling that of a serpent.

Of the former division we have the *Labridæ*. This family contains

the Wrasse (*Labrus*), a genus of fishes decked in the most lively colours; for the yellow, green, blue, and red, forming bands of spots, give the body the appearance of being enriched with brilliant metallic reflections.

We represent here, as a type of the genus, the adult Green and Red Labrus (Fig. 374), varieties of the commonest species, called the sea-parrot, the body being oblong, clothed with large scales; a dorsal fin, frequently with membranous appendages, thick fleshy lips, and large conical teeth; cheeks and gill-covers clothed with scales; gill-covers smooth at the edges; three spines in the anal fin.

IV.—Physostomata.

The principal character of the fishes of this order is that the rays of the fins are soft, except sometimes the first ray of the dorsal or pectoral. They inhabit either sea or fresh water, and include fishes of the utmost importance as human food, such as the herring, the cod, the salmon, carp, pike, and many others. Modern naturalists, following Müller, divide them into two sub-orders:—1. *Apoda*, without ventral fins; 2. *Abdominalia*, having ventral fins.

1. *Apoda.*—There are but three families in this sub-order, which comprehends great numbers both of genera and species; they are anguilliform or snake-like, elongated in form, the skin thick and soft, and have no ventral fins.

In the *Gymnotidæ* the dorsal fin is entirely wanting; the body is long, nearly cylindrical, and also serpent-like, the tail being long in comparison to the other parts of the body; beneath the tail is a long anal fin, the tail is the only locomotive organ; it is the nakedness of the back which confers its designation of γυμνὸς, *naked*, νῶτος, *back.*

The species of the genus *Gymnotus* are fresh-water fishes of South America, where they attain a great size. There are several species, but the most remarkable, from its singular physical properties, is the Electrical Eel, *Gymnotus electricus* (Fig. 375). These properties enable the Electrical Eel to arrest suddenly the pursuit of an enemy, or the flight of its prey, to suspend on the instant every movement of its victim, and subdue it by an invisible power. Even the fishermen themselves are suddenly struck and rendered torpid at the moment of seizing it, while nothing external betrays the mysterious power possessed by the animal.

The electrical properties of the Gymnotus were reported for the first time by Van Berkal. The astronomer Richer, who had been sent to Cayenne in 1671 by the Academy of Sciences of Paris, on

the Geodesic Survey, first made known the singular properties of this American fish. "I was much astonished," says this author, "to see a fish some three or four feet in length, and resembling an eel, deprive of all sensation for a quarter of an hour the arm and neighbouring parts which touched it. I was not only an ocular witness of the effect produced by its touch; but I have myself felt it, on touching one of these fishes still living, though wounded by a hook, by means of which some Indians had drawn it from the water. They could not tell what it was called; but they assured me that it struck other fishes with its tail in order to stupefy them and devour them

Fig. 375 —The Electrical Eel (Gymnotus electricus).

afterwards, which is very probable, when we consider the effect of its touch upon a man."

The observations of Richer made little impression at the time on the *savants* of Paris, and matters remained in this state for seventy years, when the traveller Condamine spoke in his "Voyage en Amérique" of a fish which produced the effects described by Richer. In 1750 a physician named Ingram furnished some new views respecting this fish, which he thought was surrounded by an electric atmosphere. In 1755 the Dutch physician, Dr. Gramund, writes: "The effect produced by this fish corresponds exactly with that produced by the Leyden jar, with this difference, that we see no luminous appearance on its body, however strong the blow it gives; for if the fish is large, those who touch it are struck down, and feel the blow on their whole body."

Many experiments followed these; but we are indebted to Alexander von Humboldt for the first precise account of this very curious fish. This celebrated naturalist read to the Institute of France an important memoir upon the electrical eel, from Bonpland's observations, the substance of which we shall give here.

In traversing the Llanas of the province of Caracas, in order to embark at San Fernando de Apure on his voyage up the Orinoco, M. Bonpland stopped at Calabozo. The object of this sojourn was to investigate the history of the Gymnotus, great numbers of which are found in the neighbourhood. After three days' residence in Calabozo some Indians conducted him to the Cano de Bera, a muddy and stagnant basin, but surrounded by rich vegetation, in which *Clusia rosea*, *Hymenæa courbaril*, some grand Indian figs, and some magnificent flowering odoriferous Mimosas, were pre-eminent. He was much surprised when informed that it would be necessary to take thirty half-wild horses from the neighbouring savannahs in order to fish for the Gymnotus.

The idea of this fishing, called in the language of the country *embarbascar con caballos* (intoxicating by means of horses), is very odd. The word *barbasco* indicates the roots of the *Lacquinia*, or any other poisonous plant, by contact of which a body of water acquires the property of killing, or at least of intoxicating or stupefying the fishes; these come to the surface when they have been poisoned in this manner. The horses chasing them here and there in a marsh has, it seems, the same effect upon the alarmed fishes. While our hosts were explaining to us this strange mode of fishing, the troop of horses and mules had arrived, and the Indians had made a sort of circle, pressing the horses on all sides, and forcing them into the marsh. The Indians, armed with long canes and harpoons, placed themselves round the basin, some of them mounting the trees, the branches of which hung over the water, and by their cries, and still more by their canes, preventing the horses from landing again. The eels, stunned by the noise, defended themselves by repeated discharges of their batteries. For a long time it seemed as if they would be victorious over the horses. Some of the mules especially, being almost stifled by the frequency and force of the shocks, disappeared under water, and some of the horses, in spite of the watchfulness of the Indians, regained the bank, where, overcome by the shocks they had undergone, they stretched themselves at their whole length. The picture presented was now indescribable. Groups of Indians surrounded the basin; the horses with bristling manes, terror and grief in their eyes, trying to escape from the storm which had surprised

them; the eels, yellow and livid, looking like great aquatic serpents swimming on the surface of the water, and chasing their enemies, were objects at once appalling and picturesque. In less than five minutes two horses were drowned. An eel, more than five feet long, glided under one horse, and discharged its apparatus through its whole extent, attacking at once the heart, the viscera, and the solar plexus of the animal, probably benumbing and finally drowning it.

When the struggle had endured a quarter of an hour, the mules and horses appeared less frightened, their manes become more erect, their eyes expressed less terror, the eels shunned in place of attacking them, at the same time approaching the bank, when they were easily taken by throwing little harpoons at them attached to long cords, the harpoon, sometimes hooking two at a time, being landed by means of the long cord. They were drawn ashore without being able to communicate any shock.

Having landed the eels, they were transported to little pools dug in the soil, and filled with fresh water; but such is the terror they inspire, that none of the people of the country would release them from the harpoon—a task which the travellers had to perform themselves, thereby receiving the first shock, which was not slight, the most energetic surpassing in force that communicated by a Leyden jar completely charged. The Gymnotus surpasses in size and strength all the other electric fishes. Humboldt saw them five feet three inches long. They vary in colour, according to age, and the nature of the muddy water in which they live. Beneath, the head is of a fine yellow colour mixed with red; the mouth is large, and furnished with small teeth arranged in many rows.

The Gymnotus makes its shock felt in any part of its body which is touched, but the excitement is greater when touched under the belly and near the pectoral fin. The Gymnotus gives the most frightful shocks without the least muscular movement in the fins, in the head, or any other part of the body. The shock, indeed, depends upon the will of the animal, and in this respect differs from a Leyden jar, which is discharged by communicating with two opposite poles. It happens sometimes that a Gymnotus, seriously wounded, only gives a very weak shock, but if, thinking it exhausted, it is touched fearlessly and at once, its discharge is terrible. Indeed, the phenomenon depends so much upon the will of the animal, that, according to Von Humboldt, if it is touched by two metallic rods, the shock is communicated sometimes by one, sometimes by the other wand, though their extremities are close together.

The experiments already related in connection with the torpedo

have been repeated here. If we place ourselves upon isolated supports, and take hold of a metallic rod, a shock is received; but no shock is received, on the other hand, if the fish is touched with a glass rod, or one covered with wax. Humboldt and Bonpland repeated this experiment many times, with decisive results. The electric organ has been carefully described by these observers. The organs extend from under the tail, occupying nearly one-half of the thickness. It is divided into four longitudinal bundles of muscles, the upper ones large, the two smaller below, and against the base of the anal fin. Each bundle consists of many parallel membranous plates, placed closely together and very nearly horizontal. These plates abut in one part on the skin, in another on the mean vertical plane of the fish. They are united to each other by an infinity of smaller plates, placed either vertically or transversely. The smaller prismatic and transversal canals, intercepted by those two orders of plates, are filled with gelatinous matter. All this organic apparatus receives many nerves, and presents, in many respects, an arrangement nearly analogous to that of the torpedoes.

Of the *Muræniidæ*, we find the Sea-Eel (*Muræna helena*). It is a serpent-like fish, of cylindrical form and delicate proportions, but strong, flexible, and active, swimming in waving, undulating movements in the water, just as a serpent creeps on dry land. The Sea-Eels have no pectoral fin, the dorsal and anal fin are re-united in the tail fin. A branchial opening is observable on each side of the body. *Muræna helena* (Fig. 376), which is an inhabitant of the Mediterranean, has only a single row of teeth upon each jaw. It attains the length of forty to fifty inches. It loves to bask in the hollows of rocks, approaching the coast in spring-time. It feeds on crabs and small fishes, seeking eagerly for polyps. The voracity of these fishes is such, that when other food fails they begin to nibble at each other's tails.

The sea-eels are caught with rod and line, or by lines and ground-bait, but their instinct is such that they often escape. When they have swallowed a hook they often cut the line with their teeth, or they turn upon it and try, by winding it round some other object, to strain or break it. When caught in a net, they quickly choose some mesh through which their body can glide.

Those who have studied the classics will remember the passionate love with which the Roman gourmet regarded these fishes. In the days of the Empire enormous sums were expended in keeping up the ponds which enclosed them, and the fish themselves were multiplied to such an extent that Cæsar, on the occasion of one of

his triumphs, distributed six thousand among his friends. Licinius Crassus was celebrated among wealthy Romans for the splendour of his eel-ponds. They obeyed his voice, he said, and when he called them they darted towards him in order to be fed by his hands. The same Licinius Crassus, and Quintus Hortensius, another wealthy Roman patrician, wept the loss of their murænas on one occasion, when they all died in their ponds from some disease. This, however, was only a matter of taste, passion, or fashion, sometimes, however, accompanied by cruelty and gross corruption.

It was thought among the Romans that murænas fed with human

Fig. 376.—The Sea-Eel (Muræna helena).

flesh were the most delicately flavoured. A rich freedman, named Pollion, who must not, however, be confounded with the orator of the name, had the cruelty to order such of his slaves as he thought deserving of death, and sometimes even those who had done nothing to excite his anger, to be thrown to them. On one occasion, when he entertained the Emperor Augustus, a poor slave who attended had the misfortune to break a precious vase; Pollion immediately ordered him to be thrown to the eels. But the indignant Emperor gave the slave his freedom, and, in order to manifest his indignation with Pollion, he ordered his attendants to break every vase of value which the freedman had collected in his mansion.

In the present day sea-eels are little esteemed in a gastronomic point of view. Nevertheless they are still sought for on the coast of Italy, and the fishermen avoid with great care the bites of their sharp teeth.

The Eels (*Anguilla*) have pectoral fins, under which are the gill-openings on each side; the dorsal and anal fins extending up to the tail, mingling with this last, which terminates in a point at the extremity. The Eels (*Anguilla*) inhabit most European rivers, except in the spawning season, when, according to some naturalists, they betake themselves to the sea. During the greater part of their existence, therefore, they have no connection with the ocean. The

Fig. 377.—The Common Conger (Conger vulgaris).

Congers, on the other hand, are fishes of great size, which inhabit the seas of warm countries, as well as those of Northern Europe. The type of this family is the Common Conger, *Conger vulgaris* (Fig. 377), which differs from the true eels chiefly in the dorsal fins, which commence very near to the pectorals; and also in their upper jaw being longer than their under one. They attain the thickness of a man's leg, and are sometimes two yards in length. The conger-eel is frequently found in salt marshes, but its flesh is held in little esteem.

2. *Abdominalia.*—The fishes belonging to this sub-order have the ventral fins placed on the abdomen, and not attached to the

bones of the shoulder. It is much the more numerous and important of the order. It includes most of our fresh-water fishes, a great number of marine species, and many like the salmon, which betake themselves to the rivers in the spawning season to deposit their ova. We shall limit our remarks to the *Salmonidæ*, the *Clupeadæ*, and a few others.

Salmonidæ.—The fishes of this family are graceful in shape, and

Fig. 378.—Adult Salmon.

have the body clothed in scales; they have two dorsals, the first with soft rays, followed by a second, which is smaller, formed without rays, and adipose—that is, formed simply of a skin filled with fatty matter, unsupported by osseous rays. They inhabit the seas of temperate and northern regions; ascending the rivers at certain seasons, and, in some instances, living exclusively in the great rivers and watercourses. They are found even in the most elevated mountain brooks. The grayling, trout, and the salmon, the type of the family, belong to the group.

The genus *Salmo* includes three well-known species, namely, *Salmo*

salar (the Salmon), *S. fario* (the Salmon trout), and *S. trutta* (the trout). Of these, *S. salar* (Fig. 370) has the body long, the muzzle roundish,

Fig. 379.- The Young Salmon.

but more so in the male than in the female, the upper jaw provided with a fossette, into which the point of the lower jaw penetrates; the

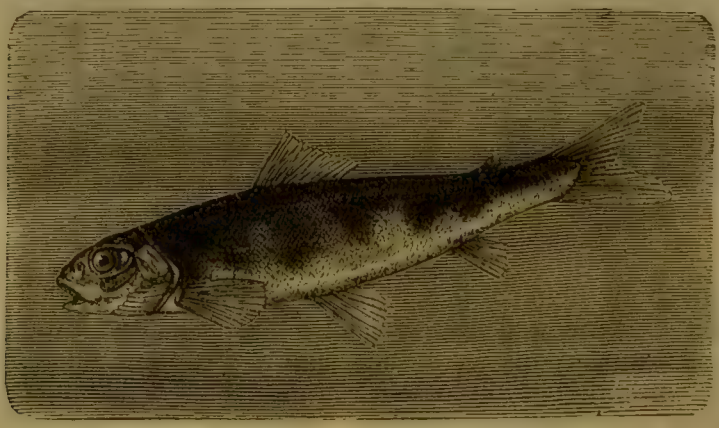


Fig. 380.—Salmon, or Parr, a year old.

back is a slaty blue, the sides and lower part of the body of a silvery diaphanous white, with great black spots scattered round the upper part of the head, round the upper edge of the eye, and over the oper-

culum or gill-cover. Some brownish irregular spots, variable both in form and size, are sprinkled over the sides. In other respects the colours are subject to variations according to circumstances. Before assuming the characters here indicated, however, the salmon has passed through three stages, each of which is marked by peculiarities worthy of being noted. The young salmon (Fig. 379) is greyish and striped with black. At the end of a year it has acquired a fine metallic hue. "The other parts," according to Mr. Blanchard, "are of a dazzling steel-blue; eight or ten large spots of the same brilliant blue cover it as with a silvery mantle on the sides; between these spots a reddish, or, rather, brightish-rusty iron colour prevails; a black spot is usually observable in the middle of the operculum. The belly is of a fine diaphanous blue in the parr" (Fig. 380).

Dr. Bertram gives a very clear and intelligible account of the early life history of the salmon, which was at one time veiled in mystery. "The spawn, deposited by the parent fish in October, November, and December, lies in the river till about April or May, when it quickens into life. I have already described the changes apparent in the salmon's egg, from the time of its fructification till the birth of the fish. The infant fry are of course very helpless, and are seldom seen during the first week or two of their existence, when they carry about with them, as a provision for food, a portion of the yolk of the egg from whence they were hatched. At that time the fish is about half an inch in size, and presents such a singular appearance that no person seeing it would ever believe that it would grow into a fine grilse or salmon. After absorbing its umbilical bag, which it takes a period of twenty to forty days to accomplish, the young salmon may be seen about its birthplace, timid and weak, hiding about the stones, and always apparently of the same colour as the surroundings of its sheltering-place. The transverse bars of the parr, however, speedily become apparent, and the fish begins to grow with considerable rapidity, especially if it is to be a twelvemonth's smolt, and this is very speedily seen at such a place as the Stormontfield ponds. The young fish continue to grow for a little more than two years before the whole number make the change from parr to smolt, and seek the salt water. About fifty days is required for the animal to assume the shape of a perfect fish; before that time it might be taken for anything else than a young salmon. At the end of two years it has changed into a smolt. Half the number of any one hatching begin to change at a little over twelve months from the date of their coming to life. And thus there is the extraordinary anomaly of fish of the same hatching being at one and the same time parr of half an ounce in

weight, and grilse weighing four pounds. The smolts of the first year return from the sea, while their brothers and sisters are timidly disporting in the breeding shallows of the upper streams." A late sea-going smolt explains the anomaly of a spring salmon.

It thus appears that, in this first stage, the young salmon (Fig. 380) is called a *parr;* during the second it is a *smolt*, namely a parr plus a jacket of silvery scales. While they continue in the state of parr they lead a secluded life, totally unable to endure salt water, which would kill them. When they have become smolts the fish betake themselves in troops to the sea. The sea-feeding being favourable, and the fish strong enough for the salt water, a rapid growth is the consequence. After that they disappear, spreading themselves over the wide world of the ocean. At the end of two months of a life mysterious and so far unknown, these fishes reappear in the rivers, returning to their native pools ; but how changed! *Quantum mutati!* The smolt, which has lived in he rivers two or three years, and only attained the length of six or eight inches, returns at the end of two months' sojourn in the sea, weighing three to four pounds, and, after six months', ten or twelve pounds. It is now a grilse.

After depositing their eggs the grilse remain some time in the fresh water, when they again go to the sea. This second sojourn, of about two months, is sufficient to send it back weighing from six to twelve pounds. It is now an adult salmon. Each new visit to the sea brings the salmon back increased in size in proportion to the duration of the voyage. In the month of March, 1845, the Duke of Athole took a salmon in the Tay after it had deposited its eggs ; he marked it by attaching a metal label to it. It weighed ten pounds. The same individual, with its metal label, was again fished up after five weeks and three days' absence. It now weighed twenty-one pounds, having in the meantime travelled forty miles down the river to the sea. This fish must, however, have made a long sea run during these thirty-eight days and its seeking up the river again.

In most circumstances, according to Mr. Blanchard, to whom we are indebted for much information relative to the development and migration of these fishes, salmon of various ages, which have nevertheless sojourned in the sea as grilse, adult salmon, and others intermediate between them, whose first sojourn at sea has extended to eight or ten months, ascend the rivers together in an order no less varied, the older individuals heading the column, the youngest bringing up the rear.

When the period for depositing their eggs approaches, a male and

female pair off, as it were; seeming to choose, by a common accord, a retired place in which to spawn. Here both male and female employ themselves in hollowing out a nest in the sand some eight or nine inches deep, wherein the female deposits her eggs, which the male fertilises by shedding a milky fluid over them, sheltering the eggs afterwards by a covering of sand.

The salmon only ascends the rivers to spawn. They eagerly return afterwards to salt water. When enjoying themselves in the water they swim slowly, floating near the surface; but in pursuit of any object, or if threatened with danger, they dart out of the water with extraordinary promptitude. The tail is, in fact, a true oar moved by powerful muscles. A low waterfall is to the salmon no serious obstacle when it is impelled to ascend to its breeding-place; curving its vertebral column, it forms itself into a sort of elastic spring; the arc of which being suddenly unbent, strikes the water with great force with the tail, and in the rebound it leaps to the height of several yards, clearing waterfalls of considerable height. If it falls without accomplishing its object, it repeats the manœuvre until it is at last successful. It is especially when the leader of the band makes a successful leap that the others, acquiring new spirit from its example, throw themselves upwards until their emulation is rewarded by success.

Fig. 381.—Salmon Leap at Kilmorack.

Some of the British waterfalls are celebrated for their salmon leaps. Wales, Scotland, and Ireland have each their celebrated leaps; in Pembrokeshire, Argyleshire, and at Ballyshannon in county Donegal, and at Leixlip near Dublin. This latter cataract is about twenty feet high, and the country people make a holiday in order to see the salmon clear its height. These acrobat fishes frequently fall before they finally succeed, and it is not unusual for the people to place osier baskets to trap them in their fall. At the cataract of

Kilmorack, in Inverness-shire (Fig. 381), the inhabitants living near the river have a practice of fixing branches of trees on the edge of the rocks. By means of these branches they contrive to catch the fishes which have failed in their leap; it is even asserted that sportsmen have been known to kill them on the wing, as it were, in their leap. But the exploit attributed to Lord Lovat by Dr. Franklin is perhaps the nearest approach to the fabulous which we have met with. Having remarked that great numbers of salmon failed in their efforts to surmount the Falls of Kilmorack, and that they generally fell on the banks at the foot of the fall, Lord Lovat conceived the idea of placing a furnace and a frying-pan on a point of rock overhanging the river. After their unsuccessful effort some of the unhappy salmon would fall accidentally into the frying-pan. The noble lord could thus boast that the resources of his country were so abundant, that on placing a furnace and frying-pan on the banks of its rivers, the salmon would leap into it of their own accord, without troubling the sportsmen to catch them. It is more probable, however, that Lord Lovat knew that the way to enjoy salmon in perfection is to cook it when fresh from the water, and before the richer parts of the fish have ceased to curd.

The principal salmon found in the market are from the Tweed, Tay, North Esk, Spey, Skye, and Norwegian rivers, and above all from the Severn and the rivers of Ireland, which latter are said to be the best which come to market. None of these must be confounded with the imported American variety—the origin of the prevalent cheap London kipper—and the Cape, or red-mouthed variety. Cape and Americans are at once distinguished by their flesh boiling a blanched white. Tweed salmon are more varied; and this river, famous in song, is also noted for its production of the greatest proportion of bull-trout. The Tay yields the largest grilse and salmon, but the Spey follows fast in her wake; Tay fish sometimes weigh sixty pounds. The minor Scotch rivers produce smaller but superior fish. Skye and West-coast grilse are short, thick, and small-headed, and proportionally more abundant. Trout are numerous; sea-bull, burn, or loch, and the so-called herring-trout, are the varieties usually met with. The whitling of the Tweed, grayling of Tay, and tinnock of North and South Esk, are young sea and bull-trout, abounding in March and April, when a sportsman will land fifty or sixty daily weighing from four ounces to a pound each. Trout flesh varies in colour from a clear white to a dark red; the North Esk red trout is most esteemed. The best run from a pound and a half to three pounds. The burn-trout is always red, and has been killed as heavy as thirty

pounds. The herring-trout, never found in English rivers, and only caught on our coast by herring-trawlers, is a special favourite: may it not be the whitling of the French rivers? In all other species colour varies with locality, and cannot be accounted for.

We have seen how rapidly the young salmon increase in size in the sea. During this stage of existence the salmon, being a carnivorous fish, rapidly develops itself from the grilse to the adult state. From a careful analysis made by Dr. Wilson Johnston, of the Bengal army, it appears that there is no recorded instance of healthy salmon partaking of herring or sand-lances; the tape-worm and other conditions of perverted appetite were found in all. Tape-worm is most common in the hybrid Norwegian, and perhaps explains the reason why Clupeadæ are sometimes found in their stomachs. Should the fish not be charged with spawn, it will shortly return to sport among the dancing waves; but if matured for breeding, at which period the female shows a dirty brown hue, and the male a black, they mate, choose a spot for the salmon nest, and there deposit myriads of ova. The longer a salmon continues in the river the duller their colour becomes; their flavour is greatly depreciated; so that Izaak Walton's statement, that "the further they get from the sea they be both fatter and better," is dead against our daily experience.

During the period of river residence salmon never feed. It avails not to argue that fear acts as an emetic and empties the stomach; the incontestable fact remains that the entire gastro-intestinal tract *ab ore ad ano* is in ninety-nine per cent. devoid of any trace of food. Juvenile experience on the part of the fish, recurring as a phantasm, causes them to snap at a shining artificial minnow or a gaudy fly, but they never rise out of the water; the bait must dip to them, and when hooked they shake the intruder as a terrier does a rat. If salmon never feed in fresh water, what is the rationale of their existing there? Well, the superabundant store of fat deposited in their areolar tissue appears to furnish a material which is functionally homologous to the fatty supply stored by the Asiatic and African doomba sheep, which is drawn upon to sustain life-action, when *névès*, avalanches, or a heavy snow-fall imprisons the crop of herbage. That continued muscular exertion can be sustained without special fatigue on non-nitrogenous diet, Fick and Wislicensus have proved by their recent ascent of the Faulhorn: it is moreover notorious that the chamois hunter and the Hindoo runner prefer fats and saccharoids. Is there any show of reason, then, why the salmon should not maintain its fresh-water muscular tear and wear by a stock of non-nitrogenous fatty

material? That such is the true philosophy of salmon river life is borne out by the following facts:—

1st. So soon as the secretions of the milt and roe become exhausted, the spent fish turn seaward to recruit.

2nd. The digestive secretions are not eliminated in the absence of food; the most recent experience of physiology finds its echo here. Your boxer trains on meat or nitrogenous aliment, but enters the list on hydro-carbons (fat, saccharines, and amylaceous substances). The salmon get into condition by immediately appropriating plenty of marine animals, enter their life-struggle of wintry months in river waters with an incorporated stock of potential calorific aliment, convertible, as occasion demands, into organic muscular mechanical effort.

The British rivers in which the salmon abound are, as we have seen, the Severn, the Wye, the Tweed, the Tay, the Don, and the Dee, with many of their tributaries; and in Ireland, the Shannon, the Suir, the Boyne, and many others. Besides these, many of the watercourses of lesser note adjoining the coast have been renowned for their salmon fisheries. Some of the Scottish rivers, especially, are famous for the size and quality as well as numbers of salmon. In days not very distant from ours, farm servants made it a condition of their hiring that salmon should not be served to them more than three days in the week. Those times are changed. In the districts in which this condition was the most stringently insisted on, the proprietors derive a princely revenue from this source alone. The Tay fisheries yield a revenue of £17,000 per annum. The Spey, for its length the richest in Scotland, produces £12,000 per annum. The river is only 120 miles from its source to the sea, and its picturesque banks are celebrated in a local ballad, which says, not very harmoniously, that

> "Dipple, Dundurcus, Dandaleith, and Dulocq,
> Are the bonniest haughs of the run of the Spey;"

but there's "no standing water in the Spey." The river drains 1,300 miles of mountains, many of whose bases are more than 1,000 feet above the level of the sea. The Tweed, which has been "poached" and plundered, by its proprietors using unfair implements, until there was scarcely a fish in its upper waters, is slowly recovering under legislative enactments, and its rental is now £7,500 per annum.

Salmon abound in the Loire and its affluents, but are not so plentiful in the Seine and Marne. They enter the Rhine and the Elbe, and most of the great rivers of the north of Europe. In France they were formerly found in the rivers of Brittany, and in the Gironde.

They are now very rare in those rivers. The coast of Picardy is well furnished, but they are rare in upper and lower Normandy. In Norway, especially in the district of Drontheim, the salmon fishery is conducted on a large scale on the sea-shore as well as in the interior waters. The Baltic is rich in salmon. Considerable fisheries are carried on in the waters of the Gulfs of Finland and Bothnia, as well as in the waters of Swedish Laponia. The takes vary greatly; in 1860 being much above the average throughout Great Britain; while in 1772 the fish were so scarce in the Tweed that it was believed they had gone off the coast. They invariably go to leeward with the wind, and have been caught 100 miles off land. Salmon are in condition at various periods of the year, apparently not depending on the latitude of the rivers. Thus, the Tay is one of the earliest rivers, while the north and south Esk are the latest, yet they debouch within a few miles of each other. It is the opinion of Mr. Joseph Johnston of Montrose (whose acknowledged fifty years' practical experience carries weight with it in all parliamentary committees on this question) that the Stormontfield ponds, by artificially rearing the parr, render them more helpless when they commence river life on their own account. As a natural result, the death-ratio is enormously increased—*cui bono?* especially when the parr have only the *option* of leaving, and are not compelled to go out. We must, therefore, receive Dr. Bertram's narrative, much as we respect his authority, with some reserve. The young will not grow, nor will a parr ever become a grilse, unless under given conditions; it is therefore an easy matter to explain the anomaly of a parr passing seaward becoming a four-pound grilse, while its twin-brother remaining in the breeding-pond is conditionally developed as only a half-ounce samlet, yet none the less a dwarfed grilse—the possibility of growth existing all the while, although it was not actively evoked by physical surroundings.

The modes of procedure in salmon fishery are very various. Spearing with tridents, and liestering with a weighted hook by torch-light—"burning the water," as the Scotch have it—as well as trammel, wear, and cruive-wear fishing, are now prohibited. Legal fishing in rivers is confined to row nets, and fly and bait rod fishing, fixtures being illegal since 1810. Wear shot; a larger and heavier row-net placed at the meeting of the waters; stake, fly, and bag-nets are used in the open sea. The latter is most in vogue, the former being almost superseded by the fly. Fixtures on the sea coast were held to be legal in Lord Kintore's case by the House of Lords in 1828, and continued so till the passing of the recent Act. By this Act all legal

modes of fishing are in action from the 1st of February to the 14th of September, a period, however, now curtailed by twenty-eight days—netting being illegal from Saturday to Monday in each week. It remains to be seen whether the gourmet will enjoy his salmon better after its Sabbath rest; perhaps its ragout will then haunt him as it did Talleyrand's abbé, who, instead of the *mea culpa* of the Confiteor, iterated, "Ah! le bon saumon! ah! le bon saumon!"

A bag-net is composed of three chambers: the first, which is the widest, is at the entrance; the next is the doubling, and is one inch to the mesh narrower than the outer. The last is the fish court, where the fish, by a simple and ingenious contrivance, are prevented from finding the door by which they entered. It is partly floated by corks and partly by an empty cask on the head or principal riding rope. It is set in the sea by ropes attached to anchors, one anchor rope to the head of the net and one on each wing at the entrance of the bag. The bag-leader is a separate net held by a rope and anchor on the land side, and is fastened to the bag-net. The principle of fishing is this: the tide makes a curve on the leader of the bag, in this curve the fish swim into the net. Bags are adapted for any kind of coast, and six or seven are run out to sea end on. Fly nets are the same as bags in principle, but slightly altered so as to adapt them for being fixed to stakes driven into the sand instead of being moored by rope and anchor; they are always used where the tide ebbs. Stake nets are expensive, and seldom used nowadays. When in fishing trim they are, however, more deadly than fly nets: their chambers are three times as large, but the principle of fishing in bag and stake nets is identical, leaders being used in all. It is noteworthy that trout are never caught in these leaders.

The Clupeadæ.—Of this family the herring is the useful and well-known type, to which also the pilchard, the shad, and the anchovy belong. The species of Clupea have the body longish and compressed, especially at the belly, where it comes to an edge; they are clothed with large scales, forming towards the belly a saw-like edge, which is very thin and easily removed. They have one dorsal fin without spinous rays, and one ventral, both placed near the middle of the body.

The Herring, *Clupea harengus* (Fig 382), is too well known to require description; its appearance is beautiful; but we shall only remark here that its back, which in the fish after death is of an indigo bluish colour, is greenish during life; the other parts vary considerably in their colours and markings, sometimes representing written

characters, which ignorant fishermen have considered to be words of mystery. In November, 1587, two herrings were taken on the coast of Norway, on the bodies of which were markings resembling Gothic printed characters. These herrings had the signal honour of being presented to the King of Norway, Frederick II. This superstitious prince turned pale at sight of this supposed prodigy. On the back of these innocent inhabitants of the deep he saw certain cabalistic characters, which he thought announced his death and that of his

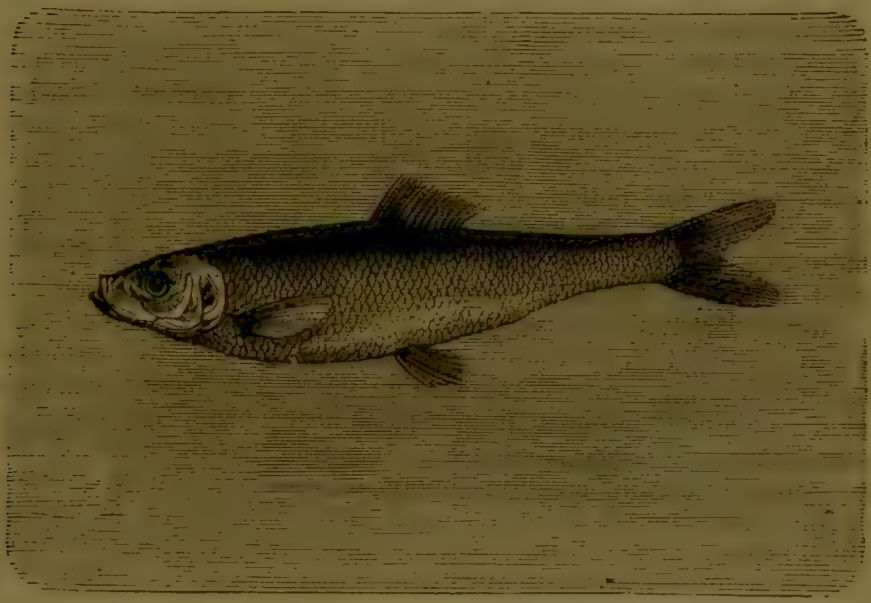


Fig. 382.—The Herring (Clupea harengus).

queen. Learned men were consulted. Their science, as reported, enabled them to read distinctly words expressing the sentiment, "Very soon you will cease to fish herrings, as well as other people." Other *savants* were assembled, who gave another explanation; but in 1588 the king died, and the people were firmly convinced that the two herrings were celestial messengers charged to announce to the Norwegian people the approaching end of the monarch.

This fish abounds throughout the entire Northern Ocean in immense shoals, which are found in the bays of Greenland, Lapland, and round the whole coast of the British Islands. Great shoals of them occupy the gulfs of Sweden, of Norway, and of Denmark, the

Baltic and the Zuyder Zee, the Channel, and the coast of France up to the Loire, beyond which they never appear to be found. But the finest herrings are said to be caught on Loch Fyne, on the west coast of Scotland.

The herrings are gregarious fishes, and live in great shoals closely packed together—shoals in which the herrings may be counted not by hundreds, but by thousands and tens of thousands, in many a shore and bay. It was the favourite theory, not very long ago, that herrings emigrated to and from the arctic regions. It was asserted, by the supporters of this theory, that in the inaccessible seas of high northern latitudes herrings existed in overwhelming numbers, an open sea within the arctic circle affording a safe and bounteous feeding-ground. At the proper season vast bodies gathered themselves together into one great army, which in numbers exceeding the powers of imagination, departed for more southern regions. This great *Heer*, or army, was subdivided, by some instinct, as they reached the different shores, led, according to the ideas of fishermen, by herrings of more than ordinary size and sagacity, one division taking the west side of Britain, while another took the east side, the result being an adequate and well-divided supply of herrings, which penetrated every bay and arm of the sea round our coast, from Wick to Yarmouth. Closer observation, however, shows that this theory has no existence in fact. Lacépède denies that these periodical journeyings take place. Valenciennes also rejects the idea. It is true that the herrings have disappeared in certain neighbourhoods in which they were formerly very plentiful; but it is also certain that in many of the fishing stations fish are taken all the year round. Moreover, the discovery that the herring of America is probably a distinct species from that of Europe (which, smoked, is known as the "Digby Chick") is against the theory. In short, there is a total absence of proof of their pretended migrations to high northern latitudes; and recent discoveries all tend to show that the herring is native to the shores on which it is taken.

"It has been demonstrated," says Dr. Bertram, "that the herring is really a native of our immediate seas, and can be caught all the year round on the coast of the three kingdoms. The fishing begins at the island of Lewis, in the Hebrides, in the month of May, and goes on as the year advances, till in July it is being prosecuted off the coast of Caithness; while in autumn and winter we find large supplies of herrings at Yarmouth: there is a winter fishery in the Firth of Forth. Moreover, this fish is found in the south long before it ought to be there, according to the emigration theory. It has been

deduced, from a consideration of the annual takes of many years, that the herring exists in distinct races, which arrive at maturity month after month. It is well known that the herrings taken at Wick in July are quite different from those caught at Dunbar in August and September; indeed, I would go further, and say that even at Wick each month has its changing shoal, and that as one race appears for capture another disappears, having fulfilled its mission. It is certain that the herrings of these different seasons vary considerably in size and appearance; localities are marked by distinctive features. Thus, the well-known Loch Fyne herring is essentially different from that of the Firth of Forth; and those differ again, in many particulars, from those caught off Yarmouth. In fact, the herring never ventures far from the shore where it is taken; and its condition, when it is caught, is just an index of the feeding it has enjoyed in its particular locality. The superiority of flavour of the herring taken in our great land-locked salt-water lochs is undoubted. Whether or not resulting from the depth and body of water, from more plentiful marine vegetation, or from the greater variety of land food likely to be washed into these inland seas, has not yet been determined, but it is certain that the herrings of our western sea-lochs are infinitely superior to those captured in the more open sea." "Moreover," he adds, "it is now known, from the inquiries of the late Mr. Mitchell and other authorities on the geographical distribution of the herring, that the fish has never been noticed as being at all abundant in the arctic regions."

The herring feeds on small crustaceans, fishes just hatched, and even on the fry of its own species. Its enemies are among the most formidable inhabitants of the ocean; the whales destroy them by thousands, but man, above all, carries on a war which almost threatens to be one of extermination. The herring-fishery has been to certain nations the great cause of their prosperity. It was the foundation of Dutch independence. Silk manufacture, coffee, tea, spices, which are productive of great commercial movements, address themselves only to the wants of luxury or fashion; the produce of the herring-fishery, on the contrary, is one of necessity to the people: and Holland would have languished and quickly disappeared, with its sinking territory, if the sea had not added to its commercial industry this inexhaustible mine of wealth. That vast field it has worked with persevering ardour. Struggling for an existence, it has conquered. Every year numerous vessels leave the coast of Holland for this precious marine harvest. The herring fishery is, for the Dutch people, the most important of maritime expeditions. It is with them known

as the "great fishery;" whaling is known as the "small fishery." The great fishery is a golden mine to Holland. It is, besides, a very ancient occupation with ourselves; we find it flourishing in the twelfth century; for, in 1195, according to the historians, the city of Dunwich, in the county of Suffolk, was obliged to furnish the king with 24,000 herrings. We also find mention made of the herring fishery in a chronicle of the monastery of Evesham in the year 709.

Towards the year 1030, the French sent vessels into the North Sea from Dieppe for this fishing, nearly a century before the Dutch made the attempt; but as early as the thirteenth century the latter enterprising people employed 2,000 boats in this industry. The Danes, Swedes, and Norwegians also occupied themselves with this trade at an early period. The French, Danes, and Swedes furnish themselves at the present time with only sufficient for home consumption. The monopoly of the foreign trade belongs to the English, Dutch, and Norwegians. "The quantity of herrings gathered every year by our neighbours beyond the Channel," says Moquin-Tandon, "is truly enormous. In Yarmouth alone 400 ships, of from forty to sixty tons, are equipped; the largest being manned by twelve men. The revenue derived from this fleet is about £700,000. In 1857, three of these fishing-boats, belonging to the same proprietors, carried home 3,762,000 fishes."

Since the beginning of this century, the Scottish fishermen have emulated the zeal of the English. In a paper communicated to the British Association in 1854, Mr. Cleghorn, who has paid great attention to the subject, states "that there are 920 Wick boats engaged in the fishing, and that the produce was 95,680 barrels" in one week alone; this being, however, a falling off of 61,000 barrels from the previous year. The cause of this immense falling off was ascribed to a storm which had swept along the coast at the height of the season; but Mr. Cleghorn was inclined to ascribe it mainly to over-fishing, which had gradually diminished the number of herrings captured.

The boats employed by the French and Dutch in the herring fishery are about sixty tons burden. They generally depart for the Orkney and Shetland Isles. They afterwards betake themselves to the German Ocean, and fish the Channel in November and December. These boats carry up to sixteen hands, according to their size. Arrived at their fishing-ground, they cast their nets, as seen in PLATE XXVI.

The lines of the Dutch fishermen are 500 feet in length, composed of fifty or sixty different nets. The upper parts of these nets are

supported by empty barrels or cork-buoys, the lower edge being weighted with lead or stones, which are kept at a convenient depth by shortening or lengthening the cords by which the buoys are attached. The size of the mesh of the nets is such that the herrings of a certain size are caught in by the gills and pectoral fins. If the first mesh is too large to hold them, they pass through, and get caught by the next or succeeding mesh, which is smaller. The herring-fishery is regulated by Act of Parliament, and the legal mode of capture is by means of what is called a drift-net. The drift-net is made of fine twine, marked with squares of an inch each, to allow for the escape of the young fish. The nets are measured by the barrel bulk, a net measuring fifty feet long by thirty-two deep, and each holding half a barrel. The drift is composed of many separate nets fastened together by means of a back rope, and each separate net of the series is marked off by a bladder or empty cask. The process is that described by Dr. Bertram in an article published in the "Cornhill Magazine." The writer had made his arrangements for a night at the herring-fishery, under the auspices of Francis Sinclair, a very gallant-looking fellow, who sails his own boat from Wick, and takes his own venture. Bounding over the waves with a good capful of wind, they had left the shore and beetling cliffs far behind them; they reached their fishing-ground, where they tacked up and down, eagerly watching for the oily phosphorescent gleam which is indicative of herrings. "At last, after a lengthened cruise," he says, "our commander, who had been silent for half an hour, jumped up and called to action. 'Up, men, and at them!' was the order of the night. The preparations for shooting the nets at once began by lowering sail. Surrounding us on all sides was to be seen a moving world of boats; many with sails down, their nets floating in the water, and their crews at rest. Others were still flitting uneasily about, their skippers, like our own, anxious to shoot in the right place. By-and-by we were ready; the sucker goes splash into the water; the 'dog,' a large inflated bladder to mark the far end of the train, is heaved overboard, and the nets, breadth after breadth, follow as fast as the men can pay them out, till the immense train is all in the water, forming a perforated wall a mile long and many feet in depth; the 'dog' and the marking-bladder floating and dipping in long zigzag lines, reminding one of the imaginary coils of the great sea-serpent. After three hours of quietude beneath a beautiful sky, the stars—

> 'The eternal orbs that beautify the night —

began to pale their fires, and, the grey dawn appearing, indicated that

it was time to take stock. We found that the boat had floated quietly with the tide till we were a long distance from the harbour. The skipper had a presentiment that there were fish in his net; and the bobbing down of a few of the bladders made it almost a certainty; and he resolved to examine the drifts. By means of the swing rope, the boat was hauled up to the nets. 'Hurrah!' exclaimed Murdoch of Skye; 'there's a lot of fish, skipper, and no mistake!' Murdoch's news was true; our nets were silvery with herrings—so laden, in fact, that it took a long time to haul them in. It was a beautiful sight to see the shimmering fish as they came up like a sheet of silver from the water, each uttering a weak death-chirp as it was flung into the bottom of the boat. Formerly the fish were left in the meshes of the net till the boat arrived in the harbour; but now, as the net is hauled on board, they are at once shaken out. As our silvery treasure showers into the boat, we roughly guess our capture at fifty cranes—a capital night's work."

But there is a reverse to this medal. Wick Bay is not always rippled by the land-breeze as on this occasion. "The herring fleet has been more than once overtaken by a fierce storm, when valuable lives have been lost, and thousands of pounds worth of netting and boats destroyed, and the gladdening sights of the herring-fishery have been changed to wailing and sorrow."

The Yarmouth boats are decked vessels of from fifty to eighty tons, with attendant boats, costing about £1,000, and having stowage for about fifty lasts; nominally, 10,000, but, counted fisherwise, 13,000, herrings, besides provision for a five or six days' voyage. Leaving a hand or two in charge of the vessel, the majority of the crew are out in the smaller boats, fishing.

The Dutch herring fishery is usually pursued during the night. When the nets are in the water, the boat is left, as we have seen in Dr. Bertram's excursion, to drift in the meantime. Each boat is furnished with a lantern, which serves the double purpose of attracting the shoals of fish, and preventing collisions with other boats. The herring fishery is extremely capricious in its results; one or two boats have been known to carry into port the whole takings of a night. Valenciennes witnessed the capture of 110,000 herrings in less than two hours. The nets are hauled in when moderately charged with fish by the crew; but it is often necessary to have recourse to the capstan in the process. Some of the hands are stationed to detach the fish from the nets; others detach the nets from the buoys; while others again fold up and stow away the nets for future use.

On the coast of Norway the electric telegraph is applied to the

herring fishery, being employed to announce to the inhabitants of the fishing towns the approach of the shoals of fish. In the fiords of Norway, where the produce of the herring fishery is the principal means of existence to nearly the entire population, it often happens that the fish make their appearance at the most unexpected times, and on some parts of the coast the shoals could only be met by one or two boats. Before the boats from the bays and fiords could take part in the fishery, the herrings had deposited their spawn and returned to the open sea.

To prevent these disappointments, often repeated with great loss to the fishermen, the Norwegian Government established, in 1857, a submarine electric cable along the coast frequented by the herrings, of 100 miles in length, with stations on shore at intervals conveniently placed for communicating with the villages inhabited by the fishermen. As soon as a shoal of herrings is known to be in the offing—and they can always be perceived at a considerable distance by the wave they raise—a telegram is despatched along the coast, which makes known in each village the approach to the bay in which the herrings have established themselves.

This important branch of industry has only assumed its real character since the fourteenth century, and its sudden and prodigious extension is due to the discovery of a simple Dutch fisherman, George Benkel, who died in 1397. To this man Holland owes much of its wealth. He discovered, in short, the art of curing the herring so as to preserve it for an indefinite time. From that moment the herring fishery assumed an unexpected importance, and became the source of much wealth to Holland and its industrious and enterprising people. Two hundred years after his death, the Emperor Charles V. solemnly ate a herring on Benkel's tomb; it was a small homage paid to the memory of the creator of an industry which had enriched his native land.

The Shad (*C. alosa*) has the body round and more plump than the herring, and is still more distinguishable by the arrangement of its teeth. More than twenty species of this genus are known, varying considerably in size. They inhabit the seas which wash the coasts of Europe, Africa, India, and America. One species is the Common Shad, *C. alosa* (Fig. 383), which is found in the Channel, the North Sea, and all round our coast. It is of a silvery tint generally, greenish on the back, with one or two black spots behind the gills. The shad approaches the mouths of rivers and great estuaries, and habitually ascends them in the spring for the purpose of depositing its ova; it is found at this season in the Rhine, the Seine, the Garonne, the

Volga, the Elbe, and many of our own rivers. In some of the Irish rivers the masses of shad taken in the seine-net have been so great that no amount of exertion has been sufficient to land them. It sometimes attains a very considerable size, weighing as much as from four to six pounds. The shad taken at sea are less delicate in their flesh than those caught in fresh-water. The habits of the shad are very imperfectly known. Two varieties are found on the British coast, namely, the Twaite Shad of Yarrell, which is about fourteen inches in length, brownish-green on the back, inclining to blue in certain lights,

Fig. 383.—The Common Shad (C. alosa).

the rest of the body silvery white, with five or six dusky spots on each side, arranged longitudinally, the jaws are furnished with distinct teeth, the tail deeply forked; and the Common or Allice Shad, which is considerably larger, sometimes attaining twelve and even fifteen inches in length, having only one spot on each side of the body near the head; the jaws are without teeth, and the scales are small in proportion. This species is plentiful in the Severn, but rare in the Thames.

The Twaite shad is found in the Severn and Thames in considerable quantities about the second week in July. They reach the fresh water about May, deposit their spawn, and return to salt water in July. Their scales are large.

The Sprat (*C. Sprattus*) has been the subject of a great controversy; one party contending that it is the young of the herring, another that it is a distinct species. Pennant, Yarrell, and many eminent naturalists adopt the first view; yet its specific characters, according to Pennant, are "greater depth of body than the young herring; gill-covers not veined; teeth of the lower jaw so small as to be scarcely sensible to the touch; the dorsal fin placed far back, and the sharp edge of the abdomen more acutely serrated than in the herring." Like the herring, they inhabit the deep water during the summer, following the shoal to the sea-shore in autumn. The sprat fishing commences in November, and continues during the winter months, when they are caught in such numbers that in some localities they have been used as manure.

In support of the view that the sprat is a good species, the serrated belly and relative position of the fins are dwelt upon, together with the instance detailed by Mr. Mitchell, the Belgian consul at Leith, who exhibited a pair of sprats, having the roe and milt fully developed.

On the other hand, the abundance of the sprat has been adduced as a reason for its being the young herring. In addition to this, anatomists declare their anatomy shows no difference but size. "As to the serrated belly," says Bertram, "we may look on that as we do on the tuck in a child's frock, namely, as a provision for growth." If this is so, Dr. Bertram's views supply material at once for thought and legislation. "The slaughter of sprats," he says, "is as decided a case of killing the goose with the golden eggs as the grilse slaughter carried on in our salmon rivers." But Dr. Bertram here overlooks a fact of which any one may convince himself, namely, that the young herrings are caught without the serrated belly; nay, the curer's purchase is regulated by the sprat's rough and the herring's smooth belly.

The Pilchard, *Clupea pilchardus* (Fig. 384), sometimes called the Gipsy Herring, visits our coasts all the year round. It was at one time thought, as the herring was, to be migratory, but, like that fish, it is now found to be a native of our own seas, and a constant inhabitant of our shores. It has been known to spawn in May, but the usual time is October; and authorities like Mr. Couch think it breeds only once a year. Its visit to shallow water causes immense excitement; persons watch night and day from the lofty cliffs along the Cornish coast, and the watchers (locally called "huers") signal the boats at sea beneath them the moment they see indications of the approach of a shoal. Mr. Wilkie Collins gives an animated picture of the "huer:*

"A stranger in Cornwall, taking his first walk along the cliffs in August, could not advance far without witnessing what would strike him as a very singular and even alarming phenomenon. He would see a man standing on the extreme edge of a precipice just over the sea, gesticulating in a very remarkable manner, with a bush in his hand, waving it to the right and to the left, brandishing it over his head, sweeping it past his feet; in short, acting the part apparently of a maniac of the most dangerous description. It would add considerably to the stranger's surprise if he were told that the insane individual before him was paid for flourishing the bush at the rate of a guinea a

Fig. 384.—The Pilchard (Clupea pilchardus).

week. And if he advanced a little, so as to obtain a nearer view of the madman, and observed a well-manned boat below turning carefully to the right and left, as the bush turned, his mystification would probably be complete, and his ideas as to the sanity of the inhabitants would be expressed with grievous doubt.

"But a few words of explanation would make him alter his opinion. He would learn that the man was an important agent in the pilchard fishery of Cornwall, that he had just discovered a shoal swimming towards the land, and that the men in the boats were guided by his gesticulations alone in their arrangements for securing the fish on which so many depend for a livelihood."

Where the pilchards come from, and whither they go, seems alike unknown. All that is certain is, that they are met with in shoals swimming past the Scilly Islands as early as July. In August the inshore fishing begins, and they appear on various parts of the coast

as far north as Devonshire and the south coast of Ireland up to October and November; no doubt those which have escaped the innumerable nets spread for them.

"The first sight from the cliffs of a shoal of pilchards," says Mr. Collins, "is not a little interesting. They produce on the sea the appearance of the shadow of a dark cloud, which approaches until you can see the fish leaping and playing on the surface by hundreds at a time, all huddled close together, and so near the shore that they can be caught in fifty or sixty feet of water. Indeed, when the shoals are of considerable magnitude, the fish behind have been known literally to force the fish in front up to the beach, so that they could be taken in baskets, or even with the hand.

"With the discovery of the first shoal, the active duties of the look-out, or 'huer,' on the cliffs begin. Each fishing village places one or more of these men on the watch all round the coast. He is, therefore, not only paid his guinea a week while he is on the watch, but a percentage on the produce of all the fish taken under his auspices. He is placed at his post, where he can command an uninterrupted view of the sea, some days before the pilchards are expected.

"The principal boat used is, at least of fifteen tons burden, and carries a large net called the 'seine,' which measures 190 fathoms in length, and costs £120—sometimes more. It is simply one long strip, from eleven to thirteen fathoms in breadth, composed of very small meshes, and furnished all along its length with cork at one edge and lead at the other. The men who cast this net are called 'shooters,' and receive eleven shillings and sixpence a week and one basket of fish out of every haul.

"As soon as the 'huer' discerns a shoal he waves his bush. The signal is conveyed to the beach by men and boys watching near him. The 'seine'-boat, accompanied by another, to assist in casting the net, is rowed out to where he can see it; then there is a pause and hush of expectation. Meanwhile the devoted pilchards press on—a compact mass of thousands on thousands of fish—swimming to meet their doom. All eyes are fixed on the 'huer;' he stands watchful and still, until the shoal is thoroughly embayed in water which he knows to be within the depths of the 'seine.' Then, as the fish begin to pause in their progress, and gradually crowd closer and closer together, he gives the signal, and the 'seine' is cast or 'shot' overboard.

"The grand object is now to enclose the entire shoal. The leads sink one side of the net perpendicularly to the bottom, the corks buoy the other to the surface of the water. When it has been taken all

round the shoal, the two extremities are made fast, and the fish are imprisoned within an oblong barrier of netting. The art is how to let as few of the pilchards escape as possible while the process is being completed. Whenever the 'huer' observes that they are startled, and separating at any particular point, he waves his bush, and thither the boat is steered, and there the net is shot at once; the fish are thus headed and thwarted in every direction with extraordinary address and skill. This labour completed, the silence of intense expectation that has hitherto prevailed is broken, there is a shout of joy on all sides—the shoal is secured.

"The 'seine' is now regarded as a great reservoir of fish. It may remain in the water a week or more; to secure it against being moved from its position, in case a gale should come on, it is warped by two or three ropes to points of land in the cliff, and is at the same time contracted in circuit by its opposite ends being brought together and passed lightly over its breadth for several feet. While these operations are being performed, another boat, another set of men, and another net, are approaching the scene of action.

"The new net is called the 'tuck;' it is smaller than the 'seine,' inside which it is to be let down, for the purpose of bringing the fish close to the surface. The men who manage this net are called 'regular sewers.' The boat is first of all rowed inside the seine-net, and laid close to the seine-boat, which remains stationary outside. To its bows one rope at the end of the tuck-net is fastened. The tuck-boat now slowly makes the inner circle of the seine, the smaller net being dropped overboard, and attached to the seine at intervals as she goes. To prevent the fish from getting between the two nets during the operation, they are frightened into the middle of the enclosure by beating the water with oars, and stones fastened to ropes, When the 'tuck' has at length travelled round the whole circle of the 'seine,' and is securely fastened to the seine-boat at the end as it was at the beginning, everything is prepared for the great event of the day—hauling the fish to the surface.

"Now all is excitement on sea and shore; every little boat in the place puts off, crammed with idle spectators; boys shout, dogs bark, and the shrill voices of the former are joined by the deep voices of the 'seiners.' There they stand, six or eight stalwart, sun-burnt fellows, ranged in a row in the seine-boat, hauling with all their might at the 'tuck'-net, and roaring out the nautical 'Yo, heave ho!' in chorus. Higher and higher rises the net; louder and louder shout the boys and the idlers; the 'huer,' so calm and collected hitherto, loses his self-possession, and waves his cap triumphantly.

'Hooray! hooray! Yoy—hoy, hoy! Pull away, boys! Up she comes! Here they are!' The water boils and eddies; the 'tuck'-net rises to the surface; one teeming, convulsed mass of shining, glancing, silvery scales; one compact mass of thousands of fish, each one of which is madly striving to escape, appears in an instant. Boats as large as barges now pull up, in hot haste, all round the nets, baskets are produced by dozens, the fish are dipped up in them, and shot out, like coals out of a sack, into the boats. Presently the men are ankle-deep in pilchards; they jump upon the benches, and work on till the boats can hold no more. They are almost gunwale under before they leave for the shore."

In the process of curing, the scene becomes doubly picturesque, but this is shore-work, with which our space forbids us to deal.

"Some idea of the almost incalculable multitude of pilchards caught on the Cornish shores," says Mr. Collins, "may be gathered from the following data: At the small fishing cove of Trereen 600 hogsheads were taken in little more than a week, during August, 1850. Allowing 2,400 fish only to each hogshead (3,000 would be the highest calculation), we have a result of 1,000,440 pilchards caught by the inhabitants of one little village alone, on the Cornish coast, at the commencement of the season's fishing."

The sardine of commerce (*Clupea sardina*) is sometimes taken in the Channel, on the coasts of Brittany and Cornwall, but is very common indeed in the Mediterranean, and on the coast of Sardinia, whence its commercial name. In Brittany floating nets are employed for its capture. The fishing is conducted in boats, each carrying five men; hundreds of these boats may sometimes be seen engaged at the same time three or four leagues from the coast, the nets being only drawn when they are fully charged, when the fish are arranged bed upon bed in osier baskets, each boat returning habitually to port when it has secured 25,000 fishes. The fishery extends over five or six months, the produce being about 600,000,000 of sardines.

The Anchovy (*Engraulis encrasicolus*) is chiefly taken in the Mediterranean, and is much sought after for its delicate flavour when salted and cured. It is a small, slender fish, about four to four and a half inches in length; head pointed, mouth very wide, gill-openings large, abdomen smooth; when living it is greenish on the back, silvery beneath; after death it changes to a bluish black. The fishery which gives the most abundant results takes place on the shores of the Mediterranean, principally on the coast of Sicily, the isles of Elba, Corsica, Antibes, Frejus, St. Tropez, and Cannes.

They are also taken on the Dalmatian coast, and in the neighbourhood of Ragusa.

The anchovy is only fit for food after being preserved and salted. The process of curing commences by throwing it into a strong brine; then, the head and entrails being removed, they are arranged in rows in barrels or boxes of tin, in alternate layers of salt and fish; finally, after some days of exposure, they are hermetically closed and despatched to market. Those prepared on the Provençal coast were formerly carried to the fair of Beaucaire, whence they found their way all over France, and to many parts of Europe. Now, the anchovies cured at Marseilles, and other Provençal ports, are sent direct to the various markets of Europe.

V. Anacanthina.

This sub-order of spineless fish contains four families, of which two, the *Ammodytidæ* and *Ophidiidæ*, are destitute of ventral fins, and two, the *Gadidæ* and *Pleuronectidæ*, which have these organs placed in the neighbourhood of the pectorals. Of the first family the best known genus is that of *Ammodytes;* here the body is elongated and serpent-like, having a continuous fin extending along the greater part of the back, with another at the opposite side, and a third or forked fin at the end of the tail. The muzzle is also long; the lower jaw longer than the upper. The Sand-eel, *A. lancea* (Fig. 385), buries itself in the sand; hence it is called the sand-eel; it hollows out a burrow for itself in the sand with its muzzle to the depth of fifteen or twenty inches, where it hunts out worms, on which it feeds, while it shelters itself from the jaws of many voracious fishes, which eagerly pursue it for its delicate flesh. In appearance the *A. lancea* is silvery blue, brighter on the lower parts than on the upper, the radiating fins on the abdomen being alternately white and bluish in colour.

The *Pleuronectidæ*, or Flat-fishes, have the body flat and greatly compressed. In the Rays the body is flattened horizontally, while in the Pleuronectidæ it is compressed laterally. The head of the fishes of this order is not symmetrical; the two eyes are placed on the same side; the two sides of the mouth are unequal.

To these peculiarities of structure we shall return when we come to observe the several types more exactly. In rest, as in motion, the flat-fishes are always turned upon their side, and the side turned towards the bottom of the sea is that which has no eye. This habit of swimming on their side is that to which they owe their name of πλευρά, side, and νέχτος, swimmers.

Their chief organ of natation is the caudal fin, but they are distinguished from all other fishes by the manner in which they use this oar. When turned upon their side this organ is not horizontal, but vertical, and strikes the water vertically up and down. They advance through the water but very slowly, compared to the motion of other fishes. They ascend or descend in the water with great promptitude, but they cannot turn to the right or left with the same facility as other fishes. This property of rising or sinking in the water with facility is the more useful to them, inasmuch as the greater part of their existence is passed at the greatest depths, where they draw themselves along the

Fig. 385.—The Sand-eel (Ammodytes lancea).

sands at the bottom of the sea, and often hide themselves from their enemies. Among the *Pleuronectidæ*, soles, turbot, flounders, and plaice may be noted.

The soles have the body oblong, the snout is round, nearly always in advance of the mouth, which is twisted to the left side and furnished with teeth on one side only, while the eyes are on the right side. The dorsal fin commences about the mouth, and extends up to the caudal or terminal fin. The Common Sole, *Solea vulgaris* (Fig. 386), is plentiful in the Channel, along our coasts, and especially in the Mediterranean. It is brown on the right and whitish on the opposite side. Its pectoral fins are spotted black; the scales rugged and denticulate; its size seems to vary according to the coast it frequents. Off the mouth of the Seine soles are sometimes taken eighteen and twenty inches in length. There are several modes of taking them,

but for commercial purposes they are taken by the trawl-net. When the ground-hook is employed it is baited with fragments of small fish. Every one knows the delicate flavour of the flesh of the sole, which, however, varies greatly in different localities, those of the Channel Islands being particularly choice.

Fig. 386.—The Common Sole (Solea vulgaris).

The Turbot, *Rhombus maximus* (Fig. 387), resembles in its general form a lozenge, whence its name of *rhombus*. Its under jaw is more advanced than the upper jaw, and is furnished with many rows of small teeth. Its fins are yellow with brownish spots. The left side is marbled brown and yellow; the right side, which is the inferior, white with brownish spots and points. The true turbot is the special delight of the epicure, and fabulous sums are said to have been given at different times by rich persons in order to secure a fine turbot.

The fish used to be taken largely on our own coasts, but now we have to rely upon more distant fishing-grounds for a large portion of our supply—large quantities coming from Holland. The turbot spawns during the autumn, and is in fine condition during spring and early summer. Mr. Yarrell says that it spawns in spring. Dr. Bertram doubts this, although he is not quite sure of the contrary, inasmuch as

Fig. 387.—The Turbot (Rhombus maximus).

"there will, no doubt, be individuals of the turbot kind, as there are of all other kinds of fish, that will spawn all the year round." The turbot abounds on our west coast, round Torbay, and off the mouth of the Seine and the Somme, from whence comes most of the fish consumed in London and Paris.

The Flounders and Plaice (*Platessa*) inhabit the northern seas of Europe. They have their eyes placed on the right side; the dorsal as well as the anal fin extending from over the eyes to the caudal fin,

both stretching out to a point towards the centre, giving a rhombic form to the fish. The jaws are furnished with a single row of obtuse teeth.

The Common Plaice, *P. vulgaris* (Fig. 388), attains the length of twelve or eighteen inches; it is brown above, spotted with red or orange. On the eye-side of the head are some osseous tubercles. The body, which is somewhat lozenge-shaped, is smooth.

The Flounders (*P. flesus*) are fresh-water fishes of small size,

Fig. 388.—The Common Plaice (Platessa vulgaris).

abundant in the Thames and many other rivers; these flounders and plaice are only second in importance to the soles and turbot among the Pleuronectidæ; the numbers of brill, flounders, dab, and plaice required being close upon a hundred million for the yearly supply of London alone.

The usual mode of capturing flat-fish is by means of a trawl-net, but many species of them may be caught with a hand-line. "A day's sea-fishing," says Dr. Bertram, in his "Harvest of the Sea," "will be chequered by many little adventures. There are various minor monsters of the deep that will vary the monotony of the day by occasionally devouring the bait. A tadpole fish, better known as the sea-devil, or angler, may be hooked; or a visit from a hammer-headed

shark, or a file-fish, will add greatly to the excitement; and if the 'dogs' should be at all plentiful, it is a chance if a single fish be got out of the sea in its integrity. So voracious are these Squalidæ, that I have often enough pulled a mere skeleton into the boat, instead of a plump cod of ten or twelve pounds weight."

The Dab, *P. limanda* (Fig. 389), is very common in the markets

Fig. 389.—The Dab (Platessa limanda).

of Paris, where it is held in great esteem. It takes its name Limanda from the hard and dentate scales on its body. It has jaws furnished with a single row of obtuse teeth; the dorsal fin only extends in front to a line with the eye, leaving an interval between it and the caudal. The form of the body is rhomboidal, as in the turbot, and the eyes are usually on the right side.

The Holibut, *Hippoglossus vulgaris* (Fig. 390), is a large fish, inhabiting the seas of Northern Europe and Greenland, where it is occasionally caught measuring seven feet, and weighing from 300

to 400 pounds. A fish of this species was brought to Edinburgh market in April, 1828, measuring seven feet and a half in length and three feet broad, weighing 320 pounds. The body of the holibut is more elongated than that of the plaice or flounder, the jaws and pharynx being armed with strong and pointed teeth.

Fig. 390.—The Holibut (Hippoglossus vulgaris).

Great quantities of this fish are caught on the Greenland and Norway coasts, and other northern regions. According to Lacépède, the natives fish for this with an implement which they call *gangnaed*. It is composed of a hempen cord 500 or 600 yards in length, to which are attached some thirty smaller cords, each furnished with a barbed hook at its extremity. The larger cord is attached to floating planks, which act as trimmers, indicating the place of this formidable engine of destruction.

XXVII.—Natives fishing for Holibut on the Greenland Coast.

The Greenlanders usually replace the hempen cords by thongs of whalebone or narrow bands of shark's skin. At the end of twenty hours these lines are drawn home, and it is not at all unusual to find five or six large holibuts caught on the hooks. PLATE XXVII. represents the native mode of fishing for holibut in the Greenland Seas.

Another mode of capturing this and other flat-fish is to spear them on their sandy beds. "No rule can be laid down," says Dr. Bertram, "for this method of fishing. It is carried on successfully by means of a common pitchfork, but some gentlemen go the length of fine spears made for the purpose, very long, and with very sharp prongs. Others, again, use a three-pronged farmyard graip, which has been known to do as much real work as more elaborate single points contrived for the purpose. The simplest directions I can give is just to spear every fish you see." M. Figuier adds, as a caution, that before attacking these fishes, body to body, it is necessary to wait till they are somewhat exhausted, otherwise they might overturn both bark and fisherman.

The Greenlanders cut the animal up, and salt the pieces; then expose them to the air, in order to dry them, preparatory to a long voyage.

In its fresh state the holibut is not very delicate, and is hard and difficult of digestion; however, its great size renders it a valuable prize. We may add that, notwithstanding its large dimensions, the holibut has deadly enemies in the dolphins, as well as in the birds which prey upon fishes on the shore. It is itself a voracious fish, devouring crabs, cod-fish, and even rays, not even sparing its own species, for they sometimes attack each other, nibbling at one another's tails or fins.

The Gadidæ embrace the whole of the Linnæan genus *Gadus*. They are found mostly in the seas of cold or temperate regions in both hemispheres, and are the objects of pursuit for which the great fisheries of Europe and America are established. They are known by the position of the ventral fin under the throat, and by the pointed character of these fins. The body is long and slightly compressed; the head well proportioned. Their fins are soft, and their scales are small and soft. The jaws have unequal-pointed teeth of moderate size, which are disposed in several rows. The gill-covers are large, and consist of seven rays. Most of the species have the dorsal fin, and two other unpaired fins besides, namely, a ventral and an anal fin. The stomach is large and the intestine long. The air-bladder large and strong, and in some cases notched on the margin. The

flesh of most of the species yields white, healthy, and agreeable food, easily separable into flakes when cooked, and easy of digestion. The family includes the several genera:—*Morrhua*, to which belongs the common cod-fish (*M. vulgaris*), the haddock (*M. æglefinus*); *Merlangus*, the whiting (*M. vulgaris* and *M. albus*); the coal-fish (*M. carbonarius*) and the pollack (*M. pollachius*); *Merluccius*, the hake (*M. vulgaris*); *Lota*, the ling (*L. molva*); *Motella*, the rock ling (*M. vulgaris*), and silver gade (*M. argenteola*); and other genera of less importance.

The head of the cod (*Morrhua vulgaris*) is compressed; the eyes placed on the side, close to each other, and veiled by a transparent membrane, a conformation which, according to Lacépède, enables the animal to swim on the surface of the water in northern regions in the midst of mountains of ice and under banks covered with snow, without being dazzled by the brilliant light; but this opinion is, indeed, unsupported by any other naturalist of note.

The jaws of the cod-fish are unequal, and among the rows of teeth with which it is armed many are mobile, and can be hidden in their cavities, or raised, according to the will of the animal. The dorsal fins are three in number, as represented in Fig. 383; the anal fins are two; pectoral fins narrow, and terminating in a point; the caudal fin slightly forked. Its colour is of an ashy grey, spotted with yellow on the back; white and sometimes reddish beneath.

The cod-fish is provided with a vast stomach, and is very voracious, feeding on fishes, crabs, and molluscs. It is so gluttonous and indiscriminating, that it will even swallow pieces of wood and other similar objects. This is essentially a sea-fish: it is never seen in fresh-water streams or rivers, remaining during the greater part of the year in the depths of the sea. Its habitual sojourn is in the portion of the Northern Ocean lying between the fortieth and sixty-sixth degrees of latitude.

In the vast range thus frequented by the cod, two large spaces are pointed out which it seems to prefer. The first extends to the coast of Greenland, and the other is limited by Iceland, Norway, the Danish coast, Germany, Holland, and the east and north coast of Great Britain and the Orkney Isles, comprehending the Doggerbank, Vellbank, and Cromer coast, together with salt-water lakes and arms of the sea, such as the Gairloch, Portsoy, and the Moray Firth, which indent the west coast of Scotland, and attract considerable shoals of cod-fish.

The second range, less generally known, but more celebrated

among sailors, includes the coast of New England, Cape Breton, Nova Scotia, and, above all, the island of Newfoundland, on the south coast of which is the famous sand-bank called the *Great Bank*, having a length of nearly 200 leagues, with a breadth of sixty-two, over which flows from ten to fifteen fathoms of water. Here the cod-fish swarm, for here they meet shoals of herrings and other animals, on which they feed. Such is, according to Lacépède, the geographical distribution of the cod-fish.

Fig. 391.—The Cod-fish (Morrhua vulgaris).

The English, French, Dutch, and Americans devote themselves to the cod-fishery on the bank of Newfoundland with inconceivable ardour. This island was discovered and visited by the Norwegians in the tenth and eleventh centuries, long before the discovery of America; but it was only in 1497, after the discoveries of Columbus, that the navigator, John Cabot, having visited these regions, gave it the name by which it has since been known, and called attention to swarms of cod-fish which inhabited the surrounding sea. Immediately after, the English and some other nations hastened to reap these

fruitful fields of fish. In 1578 France sent 150 ships to the great bank, Spain 125, Portugal 50, and England 40.

During the first half of the eighteenth century, England and her colonies, with the French, cultivated the cod-fishery.

From 1823 to 1831 France sent 341 ships, with 7,685 men, which carried into port over 50,000,000 pounds of fish, an average of about 6,000,000 pounds annually. Two thousand English ships of various sizes, manned by 30,000 seamen, are now employed in this important branch of industry.

On the coast of Norway, from the frontiers of Russia to Cape Lindesnæs, the cod-fishery is an important branch of trade, in which a maritime population of 20,000 fishermen are employed, with 5,000 boats.

The cod is taken either by net or line. The net is chiefly employed at Newfoundland. The net used is rectangular, and furnished with lead at the lower edge and cork buoys on the upper edge. One of the extremities is fixed on the coast; the other is carried seaward, following a curve taken by the boats, and the fish are attracted by drawing upon both extremities of the net; and by one stroke many boat-loads are sometimes taken.

The modern cod-smack is clipper-built, with large wells for carrying the fish alive, its cost being about £1,500. The crew usually consists of ten to twelve men and boys, including the captain. The line is also used for taking cod and haddocks. "Each man," says Bertram, "has a line of fifty fathoms in length, and attached to each of these lines are a hundred 'snoods,' with hooks already baited with mussels, pieces of herring, or whiting. Each line is laid clear in a shallow basket, and so arranged as to run freely as the boat shoots ahead. The fifty-fathom line with a hundred hooks is in Scotland called a 'taes.' If there are eight men in a boat, the length of the line will be 400 fathoms, with 800 hooks, the lines being tied to each other before setting. On arriving at the fishing-ground, the fishermen heave overboard a cork buoy, with a flagstaff about six feet in height attached to it. This buoy is kept stationary by a line, called the 'pow end,' reaching to the bottom of the water, where it is held by a stone or grapnel fastened to the lower end. To the 'pow end' is also fastened the fishing-line, which is then paid out as fast as the boat sails, which may be from four to five knots an hour. Should the wind be unfavourable for the direction in which the crew wish to set the line, they use the oars. When the line or 'taes' is all out, the end is dropped and the boat returns to the buoy. The 'pow' line is hauled up with the anchor and fishing-line attached to it. The

fishermen then haul in the line, with the fish attached to it. Eight hundred fish might be, and often have been, taken by eight men in a few hours by this operation; but many fishermen say now that they consider themselves fortunate when they get a fish on every fifth hook on an eight-lined 'taes'-line."

Hungry cod-fish will seize almost any kind of bait, and this is used either fresh or salted. The fresh bait is furnished by the herring, whiting, and capelan, a little fish which in the spring descends from the North Sea in shoals, pursued by the cod-fish. In the terror caused by the innumerable bands of their enemies, the capelans spread themselves in all the seas round Newfoundland in masses so thick that the waves throw them ashore, and they accumulate occasionally in heaps upon the sandy beach.

The principal fishery for capelan intended for bait takes place on the coast of Newfoundland. The inhabitants of these regions carry their booty to the fishermen who make Saint-Pierre their rendezvous, with whom they find ready purchasers.

The schooners, with a fair provision of bait, leave Saint-Pierre and other ports, take a north-easterly direction towards the great bank, and, having chosen their fishing-ground, cast anchor in fifty or sixty fathoms, and forthwith the crews give their sole attention to the work; some of them watch the lines, which are raised every instant, the captured fish removed, and the hooks re-baited; others subject the captured fishes to a first preparation for preserving them; they are opened, the entrails removed, and the fish split in two, and piled one on the other, and covered with salt. This labour goes on as long as the fishing lasts. The sailor is on deck night and day, covered with oil and blood, and surrounded with all sorts of offal and fish-like smells. But this alone is insufficient. Boats manned by crews of two or three sailors, are continually moving about, attending to the more distant lines, or "taes," which radiate round the ship in all directions.

One portion of the cod caught is dispatched to Europe in a fresh state, without other preparation than the salting which they receive on the deck of the schooner. But much the greater portion are carried on shore and subjected to further preparation. Saint-Pierre and Miquelon Islands, which are granted to the French fishermen on condition that no fortifications are erected on them, are resorted to for the purpose by the French fleet; St. John's, the capital, by the English. The Comte de Gobineau gives an animated picture of the whole process of curing the cod-fish in the "Tour du Monde for 1863." "The French houses which pursue this branch of trade," he

says, "belong principally to the ports of Granville and St. Brieuc; and the crews of their ships consist of two very distinct elements; the smaller portion being specially raised among the fishermen properly so called, they form the aristocracy on board; to these are added a larger number of mere labourers, who are landed on the arrival of the vessel at her port. Their functions are limited to receiving the fish from the boats, opening it, washing off the glutinous matter in the *chauffant*, putting the liver apart, and laying out the split fish between the layers of salt; finally, subjecting it to the different phases of the drying process on the strand.

"The *chauffant* is a shed raised upon piles, standing one half in the water and one half on shore; it is constructed of planks and posts, through which the air is suffered to circulate freely, but covered in with some of the ship's sails. Here the process of separating the intestines from the body of the fish and the salting process are carried on, in the midst of an atmosphere charged with all manner of disgusting smells, for the labourer is by no means delicate, and never thinks of removing the disgusting impurities which he is creating. There he stands, knife in hand, tearing and cutting out intestines and separating vertebræ, his only care being to avoid cutting himself—which is the chief danger he runs—in the midst of odours sufficient to produce suffocation.

"Connected with the platform on which this rough operation is performed is a cauldron, sunk in the earth, to receive the oil pressed out of the liver. This cauldron is surmounted by a roof some nine feet in height, in the form of an inverted cone. Here the oil which flows from the open way above is suffered to remain, after which it is drawn off into casks.

"The drying sheds, formerly of wood, are now constructed of stone, and in places well exposed to the sun, and especially to the wind. The sun, it is said, does not dry, but scorches; the wind, on the other hand, marvellously fulfils the purpose, and in order to avoid the one and court the other, an apparatus has been invented, consisting of long movable branches, which can be inclined so as to bring the wind directly upon the row of cod, in connection with the sun's rays, which are, indeed, not very formidable in this foggy region."

The cod-fish thus dried at Newfoundland are forwarded for consumption to all parts of the world; but only a small part of the products of the fishery are thus prepared. More than half the produce of the French fleet are sent to France merely salted, by ships which carry salt, bringing back fish in return to Rochelle, Bordeaux,

and Cette, where the process of curing is completed. In our home fisheries, to abbreviate slightly Dr. Bertram's account, the greater part of the cod taken are eaten fresh, but considerable quantities of the cod and ling taken on the coast are sent to market cured. The process pursued is very simple: they are brought on shore quite fresh, and are at once split from head to tail, and, by copious washings, thoroughly cleansed from all particles of blood; a piece of the backbone is cut away; they are drained, and afterwards laid down in long vats, where they are covered with salt, and kept under heavy weights. By-and-bye the fish are taken out of the vats; they are once more drained, and carefully brushed, to remove any impurity, and bleached by being spread out singly on the sandy beach or on the rocks, when thoroughly bleached, they are collected into heaps technically called *steeples*, and when the *bloom*, or whitish appearance, comes out on the fish they are ready for the market.

The cod is one of our best-known fishes, and was at one time much more plentiful and cheaper than it is now. It is a deep-water fish, found, as we have seen, in all northern seas, and in the Atlantic, but never in the Mediterranean. It is extremely voracious, greedily eating up the smaller denizens of the ocean. It grows to a large size, and is very prolific, as most fishes are. A cod's roe has been found more than once to be half the gross weight of the fish, and specimens of the female cod have been caught with upwards of 8,000,000 eggs. The fish spawn in mid-winter; but here our information ceases; when it becomes reproductive is unknown. Dr. Bertram thinks that it is at least three years old before it is endowed with the power of breeding.

The growth of the cod is supposed to be very slow. Dr. Bertram quotes the authority of a rather learned fisherman of Buckie, who had seen a cod which had got enclosed in a large rock pool, and he found that it did not grow at a greater rate than eight to twelve ounces per annum, though it had abundance of food.

On our own coast two modes of fishing are in common use: one by deep-sea lines, on each of which hooks are fastened at distances twelve feet apart by means of short lines six feet long, called on the Cornish coast "snoods." Buoys, ropes, or grapnels, are fixed to each end of the long line, to keep them from entanglement with each other. The hooks are baited with capelan, lance, or whelks, and the lines are shot across the tide about the time of slack water, in from forty to fifty fathoms, and are hauled in for examination after six hours.

An improvement has been introduced upon this mode of fishing by Mr. Cobb. He fixes a small piece of cork about twelve inches

above the hook, which suspends the bait and exhibits it more clearly to the fish by the motion of the wave. The fishermen, when not engaged in hauling, shooting, or baiting the long lines, fish with hand-lines, holding one in each hand, each armed with two hooks, kept apart by a strong piece of wire. A heavy weight attached to the lower end of each line keeps it steady near the ground, where the fish principally feed. Enormous quantities of cod, haddock, whiting, and coal-fish, with pollack, hake, ling, and torsk, are taken in this way all round our coast. Of cod-fish alone 400 to 550 have been

Fig. 392.—The Whiting (Merlangus vulgaris).

taken in ten hours by one man, and eight men have taken eighty score of cod in one day, fishing off the Doggerbank in five-and-twenty fathoms water. Latterly the Norfolk and Lincoln, and even the Essex coasts, have yielded a large supply of fish, which are caught as described, and are stowed in well-boats, in which they are carried to Gravesend, whence they are transhipped into market boats, and sent up to Billingsgate by each evening tide; the store-boats not being allowed to come up higher, as the fresh water would kill the fish.

The Haddock (*Morrhua æglefinus*) is common in our markets; it is much smaller than the cod, but in other respects not unlike it. It

frequents the same localities, and is caught with long lines baited usually with mussels; the old fish keep close in shore, and are only got with herring bait. In the village of Findhorn, Morayshire, large numbers of haddocks are dried and smoked with fumes of hard wood and sawdust. Hence the term "Finnan haddies," an article in such request at a Scottish breakfast. The village of Findhorn affords a very small portion of the haddocks sold as such, but the true "Finnans" are supposed to have the finest flavour.

The Whiting, *Merlangus vulgaris* (Fig. 392), by some amateurs considered the most delicate of all the Gadidæ, is plentiful all round our coast. It spawns in March, and the eggs are quickly hatched. It prefers a sandy shore, and is usually found some miles from the coast. It is a small fish, rarely exceeding twelve inches long, and seldom reaching two pounds in weight. The whiting is long in the body, clothed with very small, thin, and round scales; its dorsal fins are, like the cod's, three in number; it is without barbels; its upper jaw projects over the lower; it is of a silvery white, sometimes relieved by an olive tint, which is contrasted upon the back by the blackish tint which distinguishes the pectoral and caudal fins, and by a black spot which some individuals have at the junction of the pectorals with the body.

The whiting inhabits the seas which wash the whole European coast, often approaching the shore in shoals, and are taken annually in great numbers.

VI.—ACANTHOPTERYGEA.

The number of fishes belonging to this sub-order, which may be regarded as the most typical of the class, is exceedingly great. The families are also, as might be expected, very numerous. The first of these we will mention is the *Aulostomidæ*, in which the bones of the face are drawn out into a longish tube at the end of which is the small mouth. Of this family, *Fistularia tabacaria* (Fig. 393) may be considered the type. The tube of the muzzle is long and flat, and from the caudal fin springs a terminal filament nearly as long as the body. This species of pipe-fish is common at the Antilles; it attains the length of about three feet, but its flesh is leathery and insipid. It feeds upon crustaceans and small fishes, which it drags from the interstices of the rocks and stones by means of its long and taper snout.

The *Trachinidæ*, known in England as the Weevers, form another family. They are characterised by their very compressed head and the strong spines of the operculum. They are elongated

in shape, with short muzzles; they have a habit of burying themselves in the sand, and are formidable to fishermen, from the dangerous wounds they inflict with their spines. *Trachinus communis* (Fig. 394) is widely diffused in the Atlantic and Mediterranean. Another genus, *Uranoscopus*, is so named from the position of the eyes, which are directed towards the sky, from οὐρανὸς, the heavens, and σκοπέω, I regard. From this peculiar arrangement, they can only see above them. *Uranoscopus vulgaris* (Fig. 395) belongs to the Mediterranean,

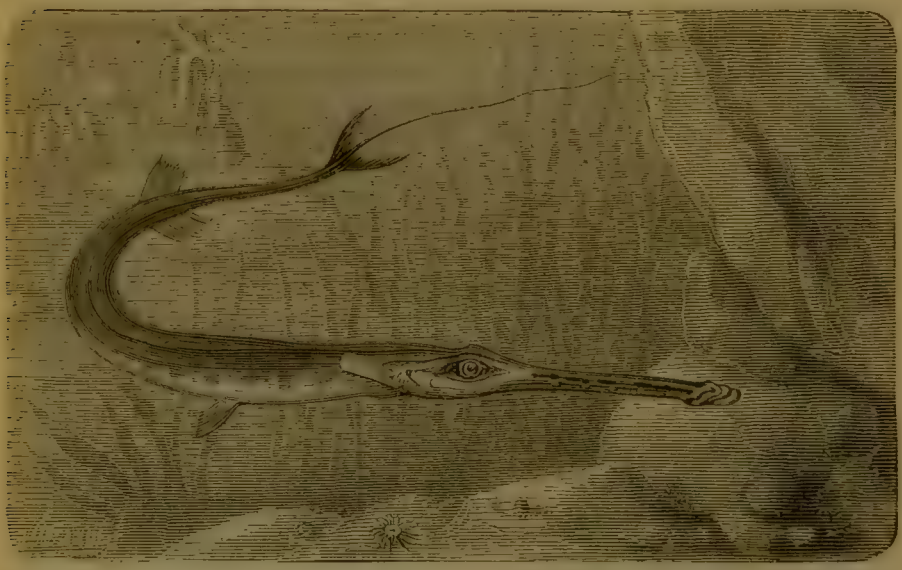


Fig. 393.—The Pipe-fish (Fistularia tabacaria.)

and is remarkable for its thick cubical head and erect spiny dorsal fins.

A third family is that of the Mullets (*Mullidæ*). They have the body thick and oblong, the profile of the head approaching the vertical line; scales large, two dorsal fins, widely separated, the rays of the first spinous, of the second, flexible; two cirri at the lower jaw. Several species are known, two are inhabitants of our west and south-west coasts: the Striped or Red Mullet (*Mullus surmulletus*). not rare as British, and the Red Mullet (*M. barbatus*). The first is a fine bright vermilion red, with three dominating yellow lines; the throat, breast, ventral, and lower surface of the tail are white, slightly tinged with rose; the fins have their rays more or less red, the iris of

the eyes a pale gold colour, just touched with red; the head bears two barbels. This beautiful fish is plentiful in the Mediterranean, and sometimes in the Channel, it is not very rare on the British coasts, is common in the gulfs of Gascony, and is frequently served on the table at Bordeaux and Bayonne, where it is known as the barbel; its flesh is a little flaky, of an agreeable flavour, but less esteemed than the red mullet.

The Red Mullet (*Mullus barbatus*) is clothed in brilliant colour of bright red, mingling with silvery tints upon the side and belly; it

Fig. 394.—The Weever-fish (Trachinus communis).

presents fine indistinct reflections, but none of the yellow lines which occur in the preceding species. It is to its brilliant colouring that the red mullet owes much of its celebrity. When we add that its flesh is white, firm, and agreeable to the taste, the estimation in which it was held by the ancients is sufficiently explained. With the Romans the mullet was an object of luxury on which they expended fabulous sums; they cultivated the fish in their fish-ponds not only as a delicacy of the table, but for the beauty of its form and colour. This fierce love of beauty, however, too often approached to cruelty. Seneca and Pliny both give us to understand that the rich patricians of Rome gave themselves the barbarous pleasure of seeing the mullet expire under their eyes, in order to witness the

various shades of purple, violet, and blue which succeed each other – from cinnabar red to the palest white—as the animal gradually loses its strength, and expires by a slow and cruel death. The great rival of Cicero, the advocate Hortensius, who attracted crowds of people to the Forum by his eloquent and elegant discourses, had an inordinate passion for this kind of enjoyment. These little inhabitants of the waters were led by a small canal, which was carried under the festive table, and his great enjoyment was to witness the agonies of

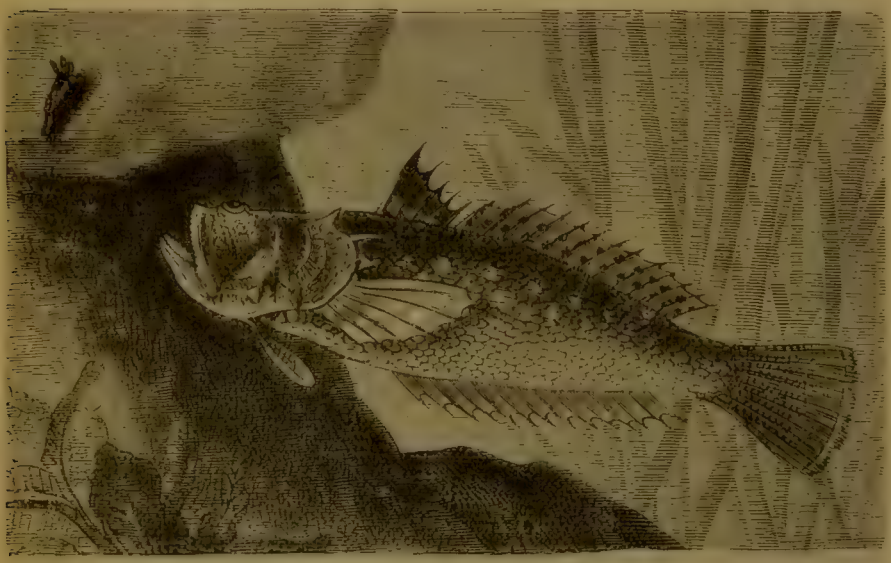


Fig. 395.—Uranoscopus vulgaris.

the unhappy fish just taken from its native element and carried to the table, palpitating with its dying convulsions, as it perished beneath his eyes, he in the meanwhile enjoying a sumptuous banquet (PLATE XXVIII.). The possession of these poor creatures had, in short, become the rage, a furious passion, and their price soon became excessive. A fish of three pounds produced a considerable sum to the fortunate fisherman, while one of four and a half pounds was simply ruinous, says Martial. Asinius Gelius purchased one for 8,000 sesterces (upwards of sixty pounds). Under Caligula, according to Suetonius, three mullets cost 30,000 sesterces (about £240). Although it is no longer the object of ferocious enjoyment on the one hand, or prodigal expenditure on the other, it is still much

XXVIII. Agnes of Red Mallet at the Table of Hermanus

sought after, both for its beauty of colour and excellent table qualities. It is found in many seas, but particularly in the Mediterranean, where it is taken all round the coast, usually in muddy bottoms; it is fished for both by line and net.

The family of the Gurnards (*Triglidæ*) is remarkable for the

Fig. 396.—The Red Gurnard (Trigla pinii).

singular manner in which the head is mailed and cuirassed; the operculum and shoulder-bones are armed with spines, having trenchant blades, which give them a disagreeable, even a hideous, physiognomy, and has procured them various names, such as sea-frog, sea-scorpion, sea-devil, and sundry other equally significant names. Even with this forbidding appearance, however, the gurnards are among the most resplendent inhabitants of the sea. Nothing can exceed the beauty of their markings; but the brilliancy with

which Nature has gifted them is their misfortune; it betrays them to their enemies, which are found in the air as well as in the water; and, without their prodigious fecundity, many species would long since have disappeared.

Many species of the genus *Trigla* are known. In the British seas the commonest species is the Grey Gurnard (*Trigla gurnardus*), a silvery-grey fish, more or less clouded with brown and speckled with black. A rare species with us, but very common in the Mediterranean, is the Red Gurnard, *Trigla pini* (Fig. 396). It is of a

Fig. 397.—The Flying Gurnard (Dactylopterus volitans).

fine bright rose-red colour, paler beneath and more vivid about the fins, of which there are two dorsal and one ventral. Beneath the pectorals are three detached rays; both jaws and front of the lower palate are armed with fine velvety teeth. The Perlon, or Sapphirine Gurnard (*T. hirundo*), is a large and handsome fish, remarkable for the lively green and blue hues of the inner surface of its large pectoral fins.

The Flying Gurnard (*Dactylopterus volitans*) somewhat resembles the Grey Gurnard, but differs in having the fin-rays of the pectorals connected by membranes, by which it is enabled to support itself some time in the air, like the flying-fish; the pectorals, when extended,

forming a sort of parachute (Fig. 397), which sustains it when it leaps out of the water. Several species are known.

All Nature seems to conspire against these singular creatures, while they have been gifted with the double power of swimming and flying. They only escape from the Bonitas, and other voracious fishes, which pursue them on the bosom of the sea, to expose themselves to the attacks of the inhabitants of the air. A crowd of sea-fowl, such as frigate-birds, the albatross, and the gulls, carry on a bloody war with them when they venture on flight. Enemies thus pursue the unhappy fish whatever element it betakes itself to. Nevertheless it passes from one element to the other with an energy which frequently defeats the attacks of its enemies. When it leaps from the sea to the height of five or six feet, it sustains itself for several hundred feet, even changing its direction. In its flight it may be compared to that of the flying dragon; the popular name given to it is said to be derived from the grunting noise they make on being taken out of the water.

Here we may also mention the singular family of the *Anabatidæ*. In the fishes of this family the superior pharyngeal bones are divided into numerous and irregular little leaflets, which form numerous cells situated under the operculum, which again serve to retain a certain quantity of water. This water preserves the gills, moreover, when the animal is on dry land, which permits them to live on shore, where they frequently contrive to creep over great distances in search of water. The genus *Anabas*, from ἀναβαίνω, to ascend, possesses this peculiarity of organisation in a remarkable degree; the Climbing Perch (*A. scandens*) is enabled to leave the rivers and marshes and little water-courses of Borneo and Java, and other islands of the Indian Archipelago, and creep through the herbage or along the ground by means of inflexions of their bodies, and by the dentation of their opercula, and by the spines of their fins. This fact, although only recently acquiesced in by modern naturalists, was well known to the ancients, and has been recorded by Theophrastus.

The great family of the Mackerels, or *Scomberidæ*, is the most important one in the order, comprehending some of the fishes most useful to man, from their size, the excellence of their flesh, and their abundance. The Tunny (*Thynnus vulgaris*), the Bonita (*Thynnus pelamys*), and the Mackerel (*Scomber scombrus*), have yielded, from the remotest antiquity, immense supplies of human food, both in the fresh and preserved state.

The tunny, while resembling the mackerel in many respects in its general form, is rounder, and attains a much larger size, being some-

times found eight and nine feet in length, and weighing 300 to 400 pounds. The upper part of the body is a bluish-black; the belly is grey, with silvery spots. These fishes sometimes present themselves in the Atlantic, but in the Mediterranean they are very abundant. At some periods of the year they approach the coast in innumerable shoals, and in numerous serried ranks, forming a vast battalion, which conceals itself under the waves, and only betrays itself on the exterior by the motion of the sea, caused by such vast numbers travelling rapidly through the water. In many localities the shoals of tunnies show themselves in the spring, pursuing their way towards the sea; and in the autumn we find them pursuing an opposite direction. We see the same thing on the coast of Provence. Upon the coast of La Ciotat a first fishing takes place from the months of March to July, and a second again from July to October. But at other points of the coast they arrive at the same time from very different directions; nevertheless, in some places they are only winter visitors.

The tunny-fishing goes back to the remotest antiquity. The Phœnicians, the first navigators known, carried it on on the coast of Spain. In our days the fishing is carried on with great activity on the coasts of Provence, of Sardinia, and Sicily.

The fishing is generally carried on by the tunny-net, but in Provence it is conducted in an enclosed pace called the *madrague*.

The tunny-net consists of a combination of nets, which is quickly cast into the sea in order to head the tunnies at the moment of their passage. When the sentinels, posted for the purpose, as in the pilchard fishery, have signalled the approach of a shoal of tunnies, and its direction, by the indications of a flag which points to the spot occupied by the finny tribe, the fishing-boats are immediately directed to the designated spot, and ranged in curved lines, forming with the light floating net a half circular enclosure, turned towards the shore, the interior of which is called the *garden*. The tunnies thus enclosed in this garden, between the coast and the net, become agitated with terror. As they advance towards the shore they press upon the enclosure, or rather a new interior enclosure is formed with other nets held in reserve. In this second enclosure an opening is left, through which the tunnies have to pass. In continuing thus to diminish the space by successive enclosures, each occupies a smaller diameter, in which the fish are enclosed in about a fathom and a half of water. At this moment a species of seine-net is thrown into the garden. This net is hauled into shallow water by the fishermen, and the small tunnies are taken by the hand, the larger by hooks. The boats are filled with them, and they are carried ashore. A single day's fishing

XXIX.—Fishing for Tunny in a Madrague, on the coast of Provence.

will sometimes produce as many as 16,000 tunnies, each from twenty to twenty-five pounds weight.

When the park, in place of being established for a single fishery, is a permanent construction in the sea, it is called, in Provence, a "madrague." The madrague is a vast enclosure. The netting which forms the partitions of its chambers are sustained by buoys of cork on the surface, and kept down by heavy stones and other weights on the lower edge, and maintained in this position by cords, one extremity of which is attached to the net, and the other is moored to an anchor. The madrague is intended to arrest the shoals of tunnies at the moment when they abandon the shore in order to return to the open sea. For this purpose a long alley or run is established between the sea-shore and the park or madrague. The tunnies follow this alley, and, after passing from chamber to chamber, betake themselves at last to the body of the park.

In order to force them into the madrague they are pressed towards the shore by means of a long net, which is extended in their rear attached to two boats, each of which sustains one of the upper angles of the net. When the fishes come to the last compartment, the fishermen raise a horizontal net, which makes a sort of false bottom to this compartment, by which the fishes are gradually raised to the surface of the water. This operation occupies the whole night.

In the morning the tunnies are collected in a very narrow space, and at varying distances from the shore; and now the carnage commences. The unhappy creatures are struck with long poles, boat-hooks, and other weapons. The tunny-fishing presents a very sad spectacle at this its last stage; fine large fish perish under the blows of a multitude of fishermen, who pursue their bloody task with most dramatic effect. The sight of the poor creatures, some of them wounded and half dead, trying in vain to struggle with their ferocious assailants, is very painful to see. The sea, red with blood, long preserves traces of this frightful carnage, of which an illustration is attempted in PLATE XXIX.

The flesh of the tunny is much esteemed, being firm and wholesome. It is called the salmon of Provence. "For our part," says M. Figuier, "we put it far above the salmon. Nothing is comparable to the fresh tunny thrown into a hot frying pan, and sprinkled with vinegar and salt. When properly cooked, nothing can be more firm or savoury. In short, nothing of the kind can rival, or even be compared, with the tunny, as we find it at Marseilles and Cette."

The tunny is greatly celebrated among the Greeks and other inhabitants on the shores of the Mediterranean, of the Propontus, and

the Black Sea. The Romans attached great value to certain parts of this fish, as the head and the lower part of the belly. The neighbouring parts were in little esteem with them. They cut them into pieces and preserved them in vases filled with salt. They are now preserved with oil and salt, before being cooked; this preparation is in great request at Cette, Montpellier, and Marseilles. With a pot of marine tunny, preserved in the vinegar of Lunel, a household is pretty well prepared for any event.

The Bonita (*Thynnus pelamys*) is not unlike the mackerel in shape, but less compressed, and upwards of twenty-five to thirty

Fig. 398.—The Mackerel (Scomber scombrus).

inches long; it is a fish of considerable size, celebrated by its pursuit in great shoals of the flying-fish (*Exocœtus volitans*). It is occasionally found on our coast, but only as an accidental visitor, for its true home is the Tropics. It is a beautiful fish of a fine blue colour, with short pectoral fins and four longitudinal bands on each side of the belly. It is easily harpooned from the dolphin-striker, and appears to have some power of generating electricity. Any one grasping the living fish is violently shaken as in palsy, so much so that the most resolute son of Neptune cannot control his speech; every attempt culminates in an unintelligible spasmodic sputter. The instant the Bonita is dropped, the muscles resume their ordinary action.

The Mackerel (*Scomber scombrus*) Fig. 398, is too well known to require minute description. Who has not admired these fishes, with their steel-blue back, and changing iridescent sides of gold and

purple and green, relieved by fine waving lines of deeper black, as they appear on the market-stalls, or as they are emptied in the early morning from the fishing-boat? The head is blue above, with black markings, the rest of the body being heightened with iridescent shades of gold and purple.

The mackerel is common to all European seas: being the *Veirat* of the Bay of Languedoc; the *Aurion* of Provence; the *Bretal* in some parts of Brittany; the *Macarello* of the modern Romans; the *Scombro* of the Venetians; the *Lacesto* of the Neapolitans; the *Cavallo* of the Spaniards; the well-known Mackerel of our own shores, and the *Makril* of the Swedes; it is found on the coast of North America, and as far south as the Canary Islands. It is a wandering, unsettled fish, supposed to be migratory, but individuals are always found on our coast. They are supposed to remain during the winter in the North Sea, and afterwards on the coast of Scotland and Ireland in January and February, on their way to the Atlantic. Here their great army is divided into two: one branch passes along the Spanish and Portuguese coasts, while the other enters the Channel. In May they appear on the coasts of England and France; in June they reach Holland; in July one portion of them returns to the Baltic, while another skirts the coast of Norway on its way to winter quarters.

Lacépède believed that this migration, which is so regular, and its stages so rigorously indicated, was irreconcilable with a great number of very precise observations; and he arrived at the conclusion that the mackerel passes the winter at the bottom of the sea, more or less remote from the coast, which they again approach in the spring. At the commencement of the fine season they advance towards the shore which best agreed with them, showing themselves often on the surface; like the tunny, traversing the sea in courses more or less direct or sinuous, but never following the periodical circle which has been so ingeniously traced out for them.

M. Milne-Edwards also remarks that, if these legions of fishes ascend from the Polar seas, they ought to visit the Orkneys before they appeared in the Channel, and enter the Mediterranean later in the season; but he is assured that they appear at the Orkneys late in the season. It appears, also, that there are different varieties which haunt the several neighbourhoods in which they abound.

The largest mackerel are taken at the entrance of the Channel, but they are considered less delicate than the smaller fishes. The shoals of mackerel, it appears, never enter the Gulf of Gascony, but they abound along the shores of Brittany up to the North Sea. It is

about the month of April that they begin to be met with, but they are then still small and without milt or roe. In the months of June and July the fish is in its most perfect state. Towards the end of September and October mackerel of the same year's hatching are taken; finally, in November and December, the fishermen still fish them, and send them to market, but this is an irregularity; and the fishermen of Lowestoft and Yarmouth take their great harvest in May and June; in the Frith of Forth, and on the north coast of Scotland, at a few weeks later.

As mackerel are very voracious, they greedily devour all sorts of bait, but they are chiefly taken by the drift-net. The drift-net is twenty feet deep and 120 feet long, well buoyed at the upper edge, but without weights at the bottom. The meshes, made of fine twine tarred to a reddish colour for preservation, are calculated to admit the head of the fish and catch it by the gill-covers so as to prevent its withdrawal. A fleet of mackerel-boats dragging these large nets, which are extended vertically in the sea, or float between the two tides, is well represented in PLATE XXX.

The flesh of the mackerel is fat and high flavoured. Among the ancients a liquid was extracted from this fat called *garum*, which was considered a very nourishing preparation. The price of this liquid was very high; in modern measures it was valued at about sixteen shillings the pint. It was acrid, half putrefied, and very nauseous, but it had the property of rousing the appetite and stimulating the digestive organs. Garum played the part of a condiment at a period when the exciting array of Indian spices was unknown. Seneca charges it, as we do pepper and other hot spices taken in excess, with destroying the stomach and health of gourmands. This garum is spoken of by the traveller Pierre Belon, writing in the sixteenth century, as being held in great estimation at Constantinople in his time. Rondelet, the author of a very remarkable book published in 1554, who ate garum at the table of William Pellicier, Bishop of Maguelonne, thought he could trace the liquid not to the mackerel, but to one of the Sparoïds (*Sparus smaris*).

The mackerel possesses phosphorescent properties, which cause it to shine in the dark, especially after death, when decomposition has commenced.

The mackerel is not only voracious, but, in spite of its small size, it has the hardihood to attack fishes much larger and much stronger than itself. It is even said that they love human flesh. According to the naturalist bishop, Pontoppidan, who lived in the sixteenth century, a sailor belonging to a vessel which had cast anchor in one

XXXII.—Fishing for Mackerel off the Cornwall Coast

of the Norwegian ports, when bathing one day in the sea, was assailed by a shoal of mackerel. His companions came to his relief; the eager band were repulsed with great difficulty, but not till it was too late: the unfortunate sailor was so exhausted that he died a few hours after. By a natural law of compensation the ubiquitous mackerel is surrounded by numerous enemies; the larger inhabitants of the ocean eagerly devour them. Certain fishes, in appearance very weak, such as the Muræna, fight them with great advantage.

Fig. 399.—The Sword-fish (Xiphias gladius).

The family *Xiphiidæ* contains the Sword-fish, *Xiphias gladius* (Fig. 399), so called from the upper jaw being elongated into a formidable spear or sword. It was known to the ancients, and has borne the name which recalls its salient characteristic from very early times. It is recognised at a glance from its peculiar appearance, and from the resemblance of its prolonged horizontal and trenchant snout to the blade of a sword. With the ancients it was Ξιφίας, and *Gladius;* with the moderns it is the Sword-fish the *Dart*, the *Spece spada*, and *l'Espadon épée.*

This fish attains a great size, being found in the Mediterranean and Atlantic, in company with the tunny, from five to six feet in length. Its body is lengthy, and covered with minute scales, the sword forming three-tenths of its length. On the back it bears a single long dorsal fin; the tail is keeled, the lower jaw is sharp, the mouth toothless, the upper part of the fish bluish-black, merging into

Fig. 400.—Fishing for Sword-fish in the Straits of Messina.

silver beneath. It seems to have a natural desire to exercise towards and against all the weapon with which Nature has furnished it; it darts with the utmost fury upon the most formidable moving bodies; it attacks the whale; and there are numerous and well-authenticated instances of ships being perforated by the weapon of this powerful creature.

In 1725, some carpenters having occasion to examine the bottom of a ship which had just returned from the tropical seas, found the snout of a sword-fish buried deep in the timbers of the ship. They

declared that, to drive a pointed bolt of iron of the same size and form to the same depth, would require eight or nine blows with a hammer weighing thirty pounds. From the position of the weapon it was evident that the fish had followed the ship while under full sail; it had penetrated through the metal sheathing, and three inches and a half beyond, into the solid frame.

The sword-fish has obstinate combats with the saw-fish, and even the shark, and it is supposed that when he attacks the bottom of a vessel he takes that sombre mass for the body of an enemy.

The flesh of the young sword-fish is white, compact, and of excellent taste; that of adults resembles the tunny. It is the object of

Fig. 401.—The Sea-Snail (Liparis barbatus).

a fishery of some importance in the Straits of Messina. The fishermen of Messina and Reggio join in this fishery with a great number of boats, carrying brilliant flambeaux, while one of the crew is stationed at the mast-head to announce the approach of the sword-fish. At a given signal the boats rush on to attack them with the harpoons (Fig. 400). During this fishery the sailors sing a peculiar melody without words.

In the family of Gobiodeæ there is a section which consists of a small number of species characterised by their ventral fins being formed into a disc with all the rays undivided, as in the sea-snails (*Liparis*), in which the lengthened body has but one long dorsal fin; the pectoral and ventrals forming a disc, as in *L. barbatus* (Fig. 401). or the Suckers (*Lepidogaster*), where the pectorals and ventrals

form two discs. In the Lump-fish, *Cyclopterus lumpus* (Fig. 402), the disc formed by the ventrals forms a sort of sucker, by which the fish attaches itself to the rocks; while the genus *Echineis* is remarkable for having on its head a disc-like sucker, which, according to M. Blainville, is an anterior dorsal fin strangely metamorphosed.

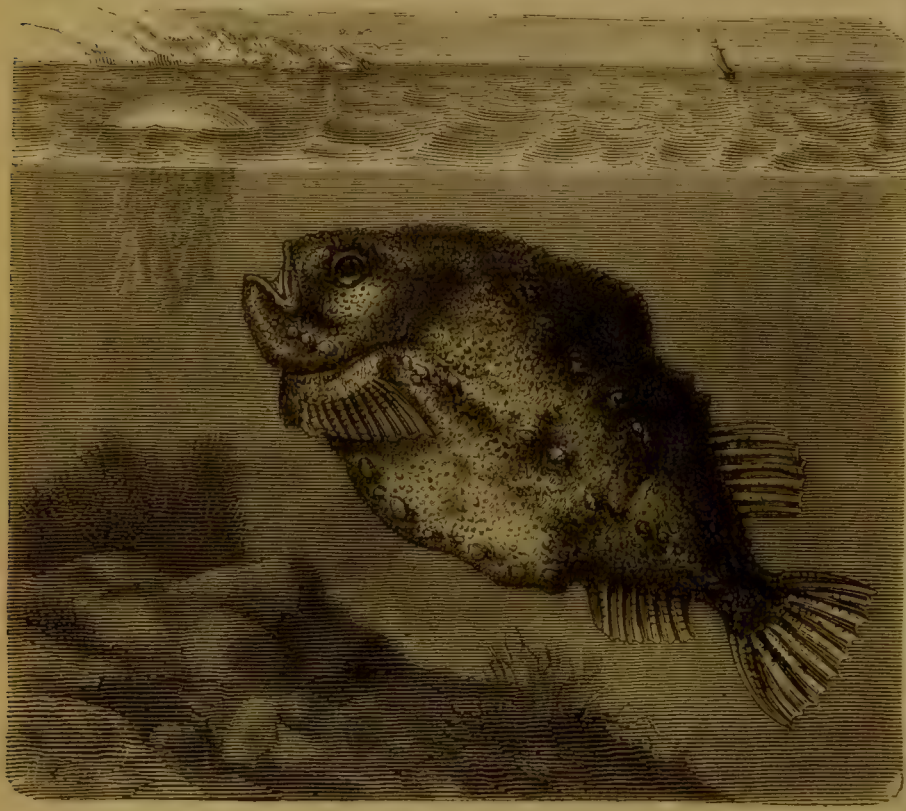


Fig. 402.—The Lump-fish (Cyclopterus lumpus).

The *Echineis remora* is an inhabitant of the Mediterranean, and abounds in the Indian and Atlantic Oceans. It is furnished with a flat disc, which covers its head, as represented in Fig. 403, which is formed of a number of transverse and movable cartilaginous plates. Aided by this organ, it attaches itself firmly to rocks, and even to ships and larger fishes, such as the Dog-fish (*Acanthius*), which it meets with in its wanderings. Its adhesion to those objects is so strong that the strength of a man fails to separate them. It invari-

ably attaches itself to the dorsum and flank of the shark, and sometimes weighs a pound and a quarter. "I have found," writes a friend, "as many as seven on one shark." It is never solitary, and makes long voyages on this monstrous animal locomotive, and that without fatigue or danger, for its enemies are kept at a distance by the formidable monster which carries it.

The family of *Lophiidæ* are particularly distinguished by having the carpal bones very long, forming a sort of arm at the extremity of which are the pectoral fins; it includes the fishing Frog (*Lophius piscatorius*), Fig. 404, remarkable for the excessive circumference of

Fig. 403.—Echineis remora.

the head and shoulders as compared with the rest of the body, the immense opening of its jaws, armed with pointed teeth, and the cutaneous jagged stripes of various lengths with which it bristles at many points. Its skin is soft, smooth, and without scales or other asperities; the carpal bones support the pectorals, and its shape and other peculiarities combine to render it a hideous and forbidding object, well calculated in ignorant and superstitious times to frighten the multitude. The remains of this fish, prepared in such a manner as to be transparent, and rendered luminous by a lamp enclosed in its interior, has often helped to deceive and frighten the timid by its fantastic appearance.

The Fishing-Frog, *Lophius piscatorius*, Linn. (Fig. 404), often attains the length of four or five feet, lives in the sand, or sunk in the mud, leaving the long and movable filaments with which the head is

furnished to float in the water; the shreds which terminate them act as natural bait when they float about in different directions, from their resemblance to worms and other marine creatures. The fishes which swim above them, and which they see very well by the assistance of their two eyes placed on the summit of the head, are attracted by these deceitful decoys. When the prey arrives near to the enormous

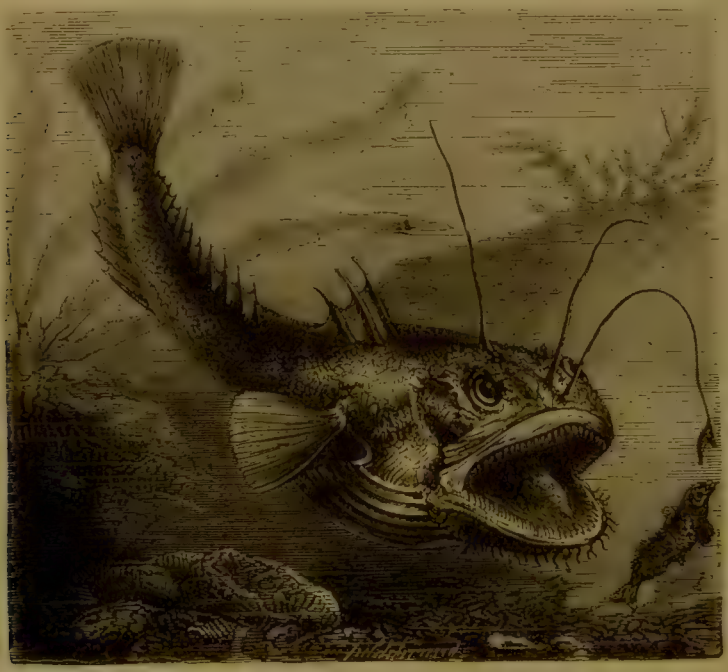


Fig. 404.—The Frog-fish (Lophius piscatorius).

jaws, which are almost always wide open, it is engulfed and torn to pieces by the strongly-hooked teeth.

This manner of lying in ambush, and fishing, as it were, with a hook and line for fishes which its conformation may not permit it to pursue, has acquired for it the name of the fishing-frog, which is sometimes given to it. It is found more or less in all parts of the Mediterranean and in many parts of the Atlantic, being frequently taken both in the Gulf of Gascony and around the British coast.

We close our abbreviated history of the Ocean and such of the inhabitants with which it swarms as seems most likely, from their

habits and other peculiarities, to interest the reader, conscious of its many imperfections. Where every creature which moves and breathes in the watery world is so full of interest, it will not surprise the reader to learn that one of the writer's chief difficulties has been that of selection, his most painful task that of rejecting the vast mass of interesting matter he had necessarily to pass in review.

We have shown in the first chapter of this work that nearly three-fourths of the surface of the earth is bathed by the sea. Struck with this vast extent of ocean, a witty French writer says, "One is almost tempted to believe that our planet was specially created for fishes." They are, indeed, a very important part of creation; they form, as it were, a bond uniting the vertebrate to invertebrate animals. They have a more complicated organisation than any of the other oceanic inhabitants (except the Cetacea), as they are also the most numerous, the most varied in form, and by far the most brilliant in colour, and the most active in their movements.

Pliny, the naturalist, describes ninety-four species of fishes. Linnæus has characterised 478. The naturalists of the present day know upwards of 13,000, a tenth of which are fresh-water fishes.

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